WORKING PAPER

Working Paper No.88

Managing Pollution in the Waterways of Madras City: An Initial Assessment

by

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Chapter I

Introduction

The Cooum River and other waterways of Madras City have been grossly polluted by large quantities of sewage, sullage, garbage and assorted urban wastes, rendering them unfit for any beneficial use. The pollution of the waterways has damaged the estuarine ecosystems, has endangered public health, and has made the waterways a liability rather than an asset of the City. There is an urgent need for managing these water resources properly, so that the waterways might enhance, rather than diminish the urban quality of life in Madras.

This research was undertaken to explore the various facets of water quality management from a socio-economic perspective. While a certain amount of technical information is provided, particularly with regard to measurement of pollution, control strategies, etc., the research methodology and framework are derived largely from the social sciences.

This report is divided into two major sections:

Section A: is an empirical enquiry into the problem of pollution of the waterways-the sources, levels, and the long-terms ecological and health impact of pollution.

Section B: is an outline of planning efforts and methodology for the control of pollution-the rationale and principles of water quality management in general; and, an appraisal of the response of the public and the Government to the specific problem of pollution of the waterways of Madras City.

SECTION A - EMPIRICAL ASPECTS

We begin the report with a description of the watershed of the Cooum. It is important to place the discussion of water quality management in a historical context, particularly because efforts to clean the Cooum were initiated more than fifty years ago. Another major reason is that the recreational and tourism potential is closely related to the geographic location of the Cooum vis-a-vis Madras City. Chapter II is an attempt to bring together these physical and social aspects, to provide the foundation and background for the problem of pollution.

In Chapter III, we discuss the causes and consequences of pollution. We attribute the problem of pollution largely to the rapid urbanisation of Madras City, and the inability of urban services to cope with such rapid growth. We discuss some of the major urban services, and the constraints faced in dealing with various urban wastes. We then provide some data on the pollution of the Cooum that has resulted from improper waste management. An integrated picture of the ecological impact of pollution is presented using data from various studies.

In Chapter IV, we discuss the "impact of pollution on human health" in some detail. The cause-effect relationship is complex, even though it stems from the intuitive notion that pollution affects human health. How exactly this occurs requires some elaboration. We begin the discussion with our earlier model of pollution as a consequence of improper waste management (Chapter III). We categorise wastes as we did earlier, in order to determine the kinds of health problems different wastes can cause, if improperly disposed. Next, we categorise

the water-related diseases that could result from improper disposal. This step is an important link in the causal chain. From empirical observations, we may know (1) that certain types of wastes are disposed improperly and end up polluting the waterways, and (2) that certain diseases are prevalent and may in fact be endemic in that areas. These two sets of observations will remain unrelated, if there is no causal link. But, we do not attempt to verify this linkage with any statistical techniques, because it would have required careful micro-level studies which are beyond the scope of this research. We conclude Chapter IV with a discussion of measures of health status such as morbidity and mortality resulting from water-related diseases in Madras City. Since there are many confounding variables such as congestion, personal hygiene, nutrition, etc. it is not possible to make conclusive statements about the health damage caused by water pollution. However, the data suggest that the high prevalence rates of water-related diseases is indicative of the gravity of the problem.

Chapters II, III and IV are an attempt to provide an integrated picture of the problem of pollution of the waterways. We have attempted to define the problem in the context of rapid urbanisation of Madras. There is sufficient empirical evidence to show that the waterways, and particularly the Cooum River, are severely polluted. We also show that there are major ecological and health consequences of pollution. Although these longer term consequences cannot be expressed precisely in monetary form, there is little doubt about the potential damage to the natural and human environment.

SECTION B - PLANNING METHODOLOGY AND APPRAISAL

In Chapter V we argue that pollution control costs are justified if they provide substantial social benefits in terms of reductions in damages to the human and natural environment i.e., there are social opportunity costs to not controlling pollution. However, we also point out that pollution control programmes may also raise questions of equity, since different groups in the population may benefit differentially, and may also have to bear differential costs. Therefore, any plan for the waterways must closely examine the social (equity) implications of the programme.

The next chapter (Chapter VI) deals with principles of water quality planning and management. Water quality management requires a broader perspective when compared to a pollution control programme. It requires consideration of interrelationships with water quantity (flood control, river management, etc), land management, solid waste management, etc. The process of water quality planning is similar to other planning processes, in the sense that we delineate various alternatives and weigh their pros and cons, before formulating a suitable "plan" or strategy. We also have to consider various management aspects - legal, institutional and financial - that must form part of the plan. We discuss all these aspects as "guiding principles" in the context of the Madras waterways.

In Chapter VII, we examine the response by the public and the Government to the problem of pollution. We first discuss the "perception" of the problem by the public, as measured by a small attitudinal survey. We then discuss the efforts of voluntary organisations to mobilise public opinion, and get the Government to undertake a clean-up programme. Such "public participation" approaches have emerged as a significant force in the shaping of public policy, particularly with regard to

the environment. We provide a brief critique of the "Citizens for Clean Waterways" compaign that was launched in 1986.

In the final chapter, we examine various technical proposals for cleaning the waterways which have been mooted by various individuals/organisations. We then discuss the report of the Taskforce setup by the Tamil Nadu Government. We provide a brief evaluation of this planning exercise using the principles developed in the Chapter VI. We also provide some further recommendations for water quality management. Some of these recommendations require detailed analysis in terms of technological feasibility and economic viability.

The major emphasis of the recommendations is on the prioritisation of various elements. In particular, controlling wastes from entering the waterways should receive the highest priority. Other measures should be phased in gradually. It is also necessary to monitor and manage the process of cleaning up the waterways. The fragmentation of responsibility and accountability will dissipate the momentum of the project. Monitoring of water quality is as important as the administrative monitoring of targets and milestones, to keep track of progress.

After the clean-up has been achieved on a sustained basis, it would be possible to use the waterways for recreation, tourism, and navigation. The development of the banks as a waterfront could be attempted at that time. These public works activities must not be at the "front-end" of the project. They will serve no purpose if the waterways remain polluted. A great deal of public funds would unnecessarily be wasted.

Thus, in Section B, we provide a planning framework for managing the problem of pollution. First, we draw on the literature to provide a rationale for pollution control, and the general principles in designing a water quality management programme. Then, we examine the actual response of the public and the Government to the problem, and conclude with an appraisal of the planning efforts undertaken so far. An epilogue has been added to provide an account of the most recent developments, which indicate that a limited but focussed approach will be employed. These developments are generally consistent with our recommendations in Chapter VIII.

SECTION A

POLLUTION OF THE WATERWAYS OF MADRAS CITY : EMPIRICAL ASPECTS

Chapter II

The Waterways of Madras City

The Cooum cannot be compared with the Yamuna or the Hooghly or the Vaigai in terms of its capacity to sustain a major urban centre on its banks. Over the years, the water flowing in the Cooum has rarely been used for human consumption. In the hinterland, it has largely been used for agriculture; but within the City, it is used mainly as a receptacle for urban drainage which is conveyed to the sea. However, the watershed of the Cooum nourished the early commercial and residential growth of Madras City. The Adyar, on the other hand, served as a southern boundary almost until independence. (Figure 1) Thus, the Cooum (or the Triplicane River as it was called earlier) played a major role in developing the urban character of Madras. The acute degradation of this important water-course is an indication of the neglect and abuse it has suffered over the years.

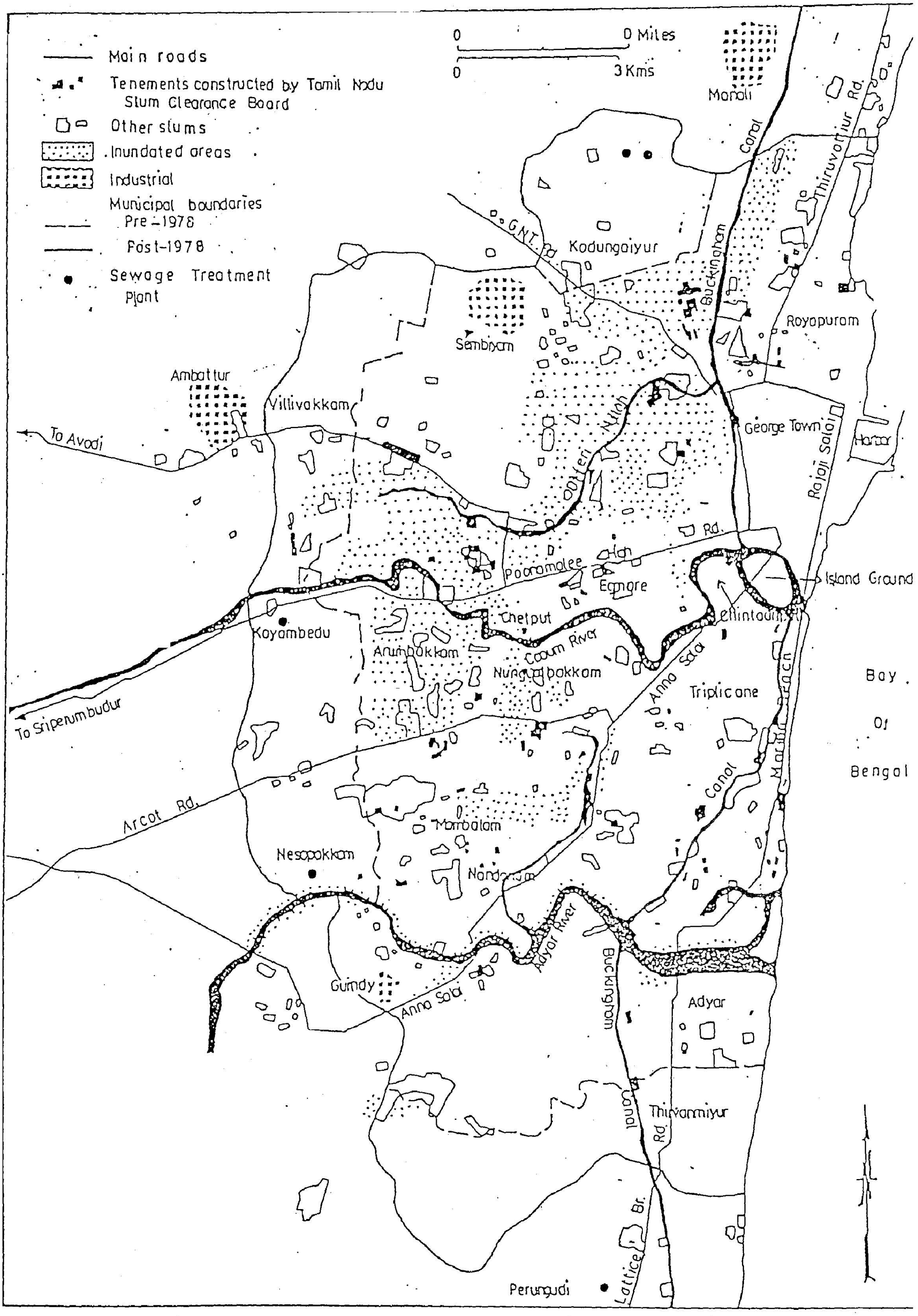
In this Chapter, we briefly trace the historical and geographical aspects connected with the Cooum. The course of the Cooum, the Buckingham Canal (which flows into and out of the Cooum) and the Adyar are described briefly. The growth of the urban watershed is mentioned to indicate the economic importance of the Cooum for tourism and recreation. Lastly, we discuss some of the improvement efforts in recent years, culminating in the present proposal to clean not only the Cooum, but also the Buckingham Canal and the Adyar. A more detailed account of recent developments will be given in later chapters.

The Course of the Cooum and the Buckingham Canal

The Cooum river is a drainage course which collects the surpluses of several tanks including the Cooum Tank near Sattarai in Tiruvallur Taluk. A connection with the River Koratalaiyar was made at the Kesavaram anicut by a man-made channel called the Old Bangaru Channel. A second anicut, the Korattur anicut, was built about 35 km downstream to divert the flow of the Cooum into the Chembarambakkam tank through the New Bangaru Channel. Throughout its course, the Cooum is largely used for agricultural purposes (Mohanakrishnan, 1986).

The River Koratalaiyar, on the other hand feeds the Poondi Reservoir, one of the sources of drinking water for Madras City. Since drinking water is a major priority, the diversion into the Cooum at Kesavaram anicut occurs only during heavy floods. The remaining flow of the Cooum, largely diverted to Chembarambakkam Tank, is currently used for irrigation, and <u>not</u> for drinking water. Thus, any additional water for low-flow augmentation or dilution of the Cooum (to improve water quality) can occur only by reducing the inflow into Chembarambakkam. In other words, water for low-flow augmentation could be provided only at the expense of irrigation. If Chembarambakkam tank is used in the future for drinking water supply, there would be yet another competing use for the water. Given the drought conditions in recent years, low-flow augmentation would probably be accorded the lowest priority among the three uses in the allocation of water resources of the Cooum.

MADRAS CITY WATERWAYS



Due to the diversion into Chembarambakkam, there is very little natural flow in the Cooum as it approaches Madras City. The river takes a meandering course, roughly West to East, of about 16 km within the City. It receives a great deal of urban drainage as it travels through major areas of the City such Arumbakkam, Aminjikarai, Chetput, Egmore, Pudupet, Chintadripet, and Island Grounds. It finally joins the Bay of Bengal near Napier Bridge. The Cooum is criss-crossed by a number of famous bridges - Monroe Bridge, Harris Bridge, Anderson Bridge, Colonel Laws Bridge, Periyar Bridge, etc.

The Cooum is also connected with the North Buckingham Canal through the Stanley viaduct. Originally, there was a river known as the North River which ran parallel to the sea, west of the Fort. In its last stages it made a S-shaped curve and joined the Cooum (known then as a Triplicane River) near its mouth. Between the Cooum and the North Rivers was a sandy piece of land which formed a peninsula. In 1696, it was felt that the two rivers should be joined by another channel, to form an island. In the early part of the eighteenth century, the Island (Wallajah) Bridge, the Willingdon (Periyar) Bridge and the Garden (General Hospial) Bridge were built to connect the Island with the mainland (Muthiah, 1987).

About hundred years later, Basil Cochrane realigned and deepened the North River and made it a navigable salt water canal upto Ennore. The Cochrane Canal as it was called then, connected with canals in the Krishna and Godavari districts of Andhra Pradesh. In 1877-78, the Duke of Buckingham who was Governor of Madras, organised a famine relief project which involved excavating a 8 km

long canal connecting the Cooum and Adyar Rivers. This canal was later connected with the South Coast canal which runs from Madras upto Marakkanam (Near Pondicherry). The 450 km long canal from Marakkanam to Pedda Ganjam in Andhra Pradesh was named the Buckingham Canal (Srinivasa Chari, 1939). Within the City, the Canal embarkments have been badly damaged, and a slum population of about 50,000 now live on the banks. Various proposals have been formulated for the improvement of the Buckingham Canal, and to revive it as a navigable waterway. The heavy pollution load of the Buckingham Canal and Stanley viaduct often end up in the estuaries of the Cooum and the Adyar, since all these waterways are interconnected. (See Figure 1).

The Adyar River:

The course of the Adyar from its source near Guduvancheri to the sea is around 40 km, and drains a catchment area of 850 sq.km. The surplus from the Chembarambakkam group of tanks also drains into the Adyar. During the monsoon season, the discharge can be quite great - of the order of 70,000 cusecs. Flooding of the banks occurs if the tanks breach.

There are a number of drains including the large Mambalam and Nandanam drains which have outlets into the Adyar. They carry sullage and stormwater which contribute to the pollution loading of the river. There are also several industrial establishments, slaughter houses, and laundries in South Madras which discharge wastes into the river.

The mouth of the Adyar (like the Cooum) tends to be closed by "littoral drift" of sand, and, has formed lagoons. Some of these lagoons have been filled up to provide land for housing. The estuary of the Adyar

still attracts a wide variety of birds. In 1987 the Forest Department declared the estuary to be a protected area. During the colonial period, there were large estates and garden houses along the Adyar. Two major bridges which have since been rebuilt-the Elphinstone (now Thiru-Vi-Ka) and the Marmalong (Maraimalai Adigal) -and a new bridge at Kotturpuram cross the Adyar.

The Urban Watershed of the Cooum

The importance of the Cooum to Madras lies in the fact that it flows through key residential and commercial parts of the City. The Cooum has been associated with the development of the City right from the beginning. Most of the garden houses of the British period came up on the southern bank of the Cooum, and, it is unlikely that it was polluted until the end of the nineteenth Century (Muthiah, op,cit.).

The Pantheon complex including the Museum, the Connemara Library, the National Art Gallery, the Museum Theatre, etc. were built in the curves of the Cooum. Other major landmarks along the Cooum are the Egmore Railway Station, and, the Women's Christian College. Victoria Crescent and the area near Connemara Hotel, continue to be important residential and commercial localities. However, beyond Harris bridge (Pudupet and Chintadripet) the watershed is extremely congested and much less attractive. The village of Chintadripet in the last loop of the Cooum was acquired and developed as a settlement for weavers, and, other workers in the textile trade. It has since become an overcrowded, congested area (Muthiah, op.cit.).

The final stretch of the Cooum between Periyar Bridge and Napier Bridge is probably the most spectacular and well known part of the river, flanked on one side by the Gymkhana Club and grounds, and on the other, by Government Estate, Cooum House, the Chepauk complex and Madras University. The other branch (connected by the Stanley viaduct) flows behind Central Jail, General Hospital and Central Station and through the Fairgrounds. The two branches meet near Napier Bridge, after which the Cooum joins the sea near the Anna Samadhi. The mouth of the Cooum is generally blocked by a sand-bar causing stagnation in the estuarine area.

The stretch of the Cooum in the heart of the City (from Napier Bridge to Chetput Bridge) is invaluable for tourism and recreation. Tourists could hava a glimpse of many important land marks of the City by taking a boat-ride, if the river were unpolluted, and, if there was sufficient water for boating. The land on both sides of the river could be developed as park areas. Thus, the river has extensive untapped recreational and commercial potential, which constitutes a major social opportunity cost for the City.

<u>Improvements to the Cooum</u>

"The Cooum River has been presenting a problem of great difficulty owing to its having become narrowed and silted up in the course of its channel and sand-barred at its mouth. The Buckingham Canal and this river emit an evil odour, especially in the hot season when the water level is very low. Some years ago a scheme was tried for pumping sea water into the river and thus enabling its level to rise and the volume of its flow to become large enough to burst the bar at the mouth whereby the sea water could rush in and carry back the

dirty water of the channel". (Srinivasa Chari, op.cit.)

So, wrote C.S. Srinivasa Chari in 1939 in the Tercentenary Celebration Volume on the "History of Madras City". Very little has changed since then, except that the levels of pollution have become much worse. Even the hardiest species of filter-feeding shell-fish cannot survive in the estuary of the Cooum. When the sand-bar blocks the mouth, there is virtually no dissolved oxygen in the water, which means that the Cooum is biologically a 'dead' river. (Azariah, 1981).

During 1967-72, the Government of Tamil Nadu undertook a major improvements scheme costing Rs.2.29 crores. Channelisation was done from Chetput Bridge upto the mouth. The Central Channel was excavated, and lining was provided for both sides. In addition, boat jetties and other amenities for boating were provided in this stretch. A regulator was installed at the mouth to flush the river periodically. In addition, a sand-pump was used to prevent the accumulation of sand at the mouth, which reduces the efficiency of flushing.

The improvement scheme was a failure for two major reasons. First, the sand-pump did not work in a satisfactory manner resulting in the reformation of the sand-bar. Second, no serious attempt was made to reduce the pollution <u>entering</u> the river. The combination of these two factors has led to the stagnation of highly polluted water in the estuary, and other reaches of the river inside the City. The stagnation causes the sludge to settle on the river bed, which is then followed by anaerobic degradation. The release of obnoxious gases during the latter process is reminiscent of the 'evil odour' mentioned by Srinivasa Chari. The stagnant

water is potentially a major public health hazard, and a breeding ground for mosquitoes. The high incidence of water-related diseases in Madras is one indication of the gravity of the problem.

No further improvement schemes were considered for more than a decade. In September 1986, the Government of Tamilnadu consituted a task-force chaired by the Chief Secretary to study the problem of the waterways.

The task-force felt that any programme to improve the waterways, must include plans for the Cooum, the Adyar, the Buckingham Canal and the Otteri Nullah (a small drainage course which discharges into the Buckingham Canal), since all these waterways are inter-connected. A detailed discussion of the working of the task-force is given in Chapters VII and VIII. Based on the recommendations of the task-force, the State Government of Tamilnadu and the Government of India approached the British Overseas Development Authority (ODA) for technical and financial assistance. In 1988, an aggrement was reached by which the ODA will provide consultancy services costing about Rs.2 crores over a three-year period, for the control of pollution of the waterways. We discuss the terms of this agreement briefly in the Epilogue.

In the remainder of Section A, we will discuss various empirical aspects of the problem. In particular, we will focus on the environmental and health impacts caused by pollution of the waterways.

Chapter III

Pollution of the Waterways : Environmental Impact

Introduction

The pollution of the Cooum and other waterways has occurred largely with the urban growth of Madras City. The rapid increase in population, and, the proliferation of urban activities had led to the generation of a variety of wastes. Since many of these wastes (human, cattle, industrial, etc.) are disposed improperly, they end up polluting the waterways.

In this chapter, we first discuss the process of rapid urbanisation in Madras, the inability of urban services to cope with such rapid growth, and the consequent pollution of the waterways by different types of wastes. Next, we review some of the studies concerned with measurement of pollution of the Cooum. Most of them provide substantial evidence that the Cooum is heavily polluted by sewage and other urban wastes. We conclude this chapter with a brief discussion of the ecological impact of pollution at the Cooum estuary.

In this chapter, we use some technical terms that may need clarification. A glossary is provided for this purpose at the end of the report.

Environmental Aspects of Rapid Urbanisation

The British initially established Madras as a trading port during the seventeenth century. Although the location of Madras is well suited for purposes of administration and trade, its natural environment has not been conducive for urban development. The flat terrain with numerous canals and water tanks has caused several environmental and hydrological problems, as the

city has grown. Many of the tanks have either silted up or have been filled up to provide urban land. The result has been heavy inundation of low-lying areas during the monsoon season.

Despite heavy rainfall, Madras has chronic water shortage due to inadequate storage and percolation. The flatness of the terrain also poses difficulties in transporting sewage and other wastewater. A relay system of pumping stations collects the sewage, and transports it to sewage treatment plants located in the periphery. During times of peak flow and during heavy rainfall, the pumping stations overflow, causing pollution of the waterways.

Urban services such as water supply, sewerage, stormwater drainage, and garbage collection have not been able to keep pace with the rapid urbanisation that has occured over the last fifty years. As shown in Table 1, the growth of Madras City was slow from 1871 (when the first census was taken) to 1931. During this period of sixty years, the population barely doubled. During the next fifty years, the population increased almost five-fold from 0.7 million to 3.3 million. The most rapid growth occurred during 1941-51 and also during the sixties. The water supply and sewerage systems which were developed at the turn of the century, did not include the potential provision of services for such a large city. Although major efforts have been taken since then to cater to the needs of a rapidly growing population, there is always a discrepancy between demand and supply. A major consequence of this strain on urban services has been the gradual degradation of the natural environment, and in particular, the pollution of land and water.

TABLE 1

Growth of Population of Madras City, 1871-1981

Year	Population	Decadal variation (Percentage)	Source of Data
1871	397,552	-	1
1881	405,848	2.09	2
1891	452,518	11.50	2
1901	552,899	22.18	3
1911	575,377	4.07	3
1921	591,536	2.81	3
1931	733,552	24.01	3
1941	881,485	20.17	3
1951	1,416,056	60.64	3
1961	1,729,141	22.11	3
1971	2,469,449	42.81	4
1981	3,266,034	32.25	5

Source: 1. Srinivasachari C.S. (1939)
2. Census of India (1891)
3. Census of India (1961)
4. Census of India (1971)
5. Census of India (1981)

Note: The area of Madras City in 1871 was around 89 sq.km and in 1981 was 172 sq.km due to expansion of the city limits.

Urban Services

We will now briefly describe the urban services that are most closely associated with the pollution of the Cooum and other waterways viz. water supply, sewerage, stormwater drainage, and, garbage collection and disposal. The first two services are provided by the Madras Metropolitan Water Supply and Sewerage Board (MMWSSB or Metrowater), while the latter two are provided by the Madras Corporation.

a) Water Supply

The Madras water supply system dates back to 1866, when it was first decided to draw water from the Koratalaiyar River. A weir was built at Tamarapakkam north-west of Madras City to divert water into a channel leading to the ancient Cholavaram and Red Hills Storage Tanks. In 1914, the Kilpauk Water Works was built to filter and pump the water for distribution throughout Madras City. Subsequently, the Poondi Reservoir was also added to the water supply system. The irrigation rights which originally existed have all been acquired, and, the three reservoirs are exclusively used for water supply. However, all three are extremely shallow and subject to high annual evaporation. As mentioned earlier, Chembarambakkam Tank the largest tank in the State, is <u>currently</u> used only for irrigation.

Groundwater sources have been developed in Minjur, Panjetty and Tamarapakkam in the north-west. The south coast aquifer provides some water to South Madras areas like Thiruvanmiyur. There are also plans to tap groundwater in the Palar basin. The inadequacy of piped water supply has resulted in the construction of thousands of shallow wells and tubewells by private parties. The

total yield of these wells is estimated to be 10 million litres per day. Water from these wells is of very poor quality, and, cannot be used for drinking. Some industries have their own wells, which provide about 43 million litres per day (World Bank, 1987).

The yield from all sources of surface and groundwater is 293 million litres per day. The per capita supply of 78 litres per day is the lowest for any metropolitan area in India. Even this low level of supply can be maintained only during years of normal rainfall. Droughts have occured in 1983, 1984 and in 1987. Supply was provided only on alternate days, and, lorries and tankers had to be used to service outlying areas due to reduced water pressure in the system. There are plans to bring water from distant sources such as the Krishna River in Andhra Pradesh.

In later chapters, we will discuss some of the implications of such a low level of water supply. An inadequate quantity of water is a major contributing factor to the transmission of certain waterwashed diseases. It would also be very difficult to release water for low-flow augmentation to maintain water quality in the waterways. There is, therefore, an urgent need to treat and reuse wastewater to the maximum extent possible, to provide water for lower grade uses such as low-flow augmentation, industrial cooling, etc.

b) Sewerage

The existing sewerage system consists of:

(i) collection of sewage in gravity sewers leading to 61 pumping stations;

(ii) Pumping stations and forcemains for pumping sewage to one of five treatement plants; and

(iii) treatment and ultimate disposal.

The original sewerage system was developed around 1911. The underground sewers were intended primarily to convey sewage waste. The scheme was based upon pumping, and hence it was decided to prevent rainwater from getting into the sewers. The rain water from the road surface and the excess rain water from houses was supposed to flow through open drains into the nearest water-course (Srinivasachari, 1939).

Originally, the entire sewage flow was conveyed to North Madras and dhscharged directly into the sea near Kasimode (Royapuram). The City has now been divided into five treatement and collection zones. Sewage from each zone is pumped to treatment and disposal sites. Part of the sewage is used to irrigate grass. The treatment technology and capacity of each of the plants is shown in Table 2. The final effluent is discharged into the nearest available water body. If the level of treatment is high enough, the effluent will not be polluting, and will infact increase stream flow during the dry season. The secondary treated waste water (33 mld) from the Kodungaiyur plant in North Madras will be made available for cooling water for the expanding industries in the Manali area. Such reuse will reduce the demand on high quality ground water for cooling. The treated sewage from the Koyambedu plant (in the Western zone) will be used for truck-washing at the wholesale market complex. There is also a pilot plant for energy recovery from sewage sludge at the Nesapakkam Plant.

TABLE 2

SEWAGE TREATMENT SYSTEM CAPACITY

No	Treatment Plant	Receiving waters	Capacity (mld)	Technology
1.	Kodungaiyur I	N.Buckingham Canal	80	Trickling Filter
2.	Kodungaiyur II	-do-	80	-do-
3.	Koyambedu	Cooum	34	-do-
4.	Nesapakkam	Adyar	22	Activated Sludge
5.	Perungudi	Backwaters	45	Sedimentation Tank.
		Total	261	

About 15% of the population of Madras City (about 0.4 million is not directly connected to the sewerage system. They live in slum areas or in other older parts of the City which are not sewered. Low cost sanitation techniques such as pit latrines and septic tanks have not worked very well because of the poor permeability of the clayey soil, and the high water table (World Bank, op.cit).

Deficiencies in the sewerage system are a major cause of pollution of the Cooum and the other waterways. The MMWSSB is cognizant of this fact, and has undertaken improvement works for collection, transmission and treatment at a total cost of Rs.23.80 crores during the period 1978-85. Seventh Plan proposals costing Rs.31.03 crores are currently being implemented (Daivamani, 1986). The World Bank has proposed a water supply and Sanitation Project, which includes improvements to the sewerage system and

will provide services to slums and low-lying areas. The sewerage component alone has a cost of $11.3 million, out of a total project cost of $112.2 million (World Bank, 1987). Implementation of all these schemes will decrease the pollution entering the waterways.

c) Drainage

As mentioned earlier, Madras City has "separate" systems of sewerage and stormwater drainage. The total length of stormwater drains is about 507 km, leaving a balance of 533 km of roads that require drains, (Task Force Report, 1987). Despite the separate systems, there is interlinking of stormwater and sewage at a large number of locations; the result is that 10-15% of stormwater drains are never dry. There are also a number of illegal house connections to stormwater drains, (Daivamani, 1986).

When flooding occurs in areas not having stormwater drains, there is tampering of manhole covers and consequent inflow into the sewerage system. This causes an overload of the sewerage system, resulting in pollution of the waterways.

The process of urbanisation has resulted in large areas of the City becoming impervious. It has been estimated that more than 85% of Madras City is covered by either black-topped roads or buildings, (Somanathan, 1987). There is very little open area for natural percolation of rainwater. Since Madras receives most of its rainfall in short bursts during the monsoon, the lack of adequate permeable surfaces, results in flooding of low-lying areas. There is, therefore, a critical need to provide drainage for the City as a whole. Unfortunately, while localized flooding is reduced by drainage, the opportunity for percolation is also reduced, limiting the extent of recharge of the aquifers.

A second problem with stormwater drainage is that all the street surface contaminants get washed into the drains and into the waterways. There is no provision at the present time for even primary treatment (such as grit filters or sedimentation tanks) for stormwater runoff. It is not often recognized that stormwater can be highly polluting.

Apart from building more stormwater drains, there are currently no plans for treatment of stormwater, so that it does not pollute the waterways. The situation is compounded further by an institutional problem. While water supply and sewerage are the responsibility of the MMWSSB, stormwater management is the responsibility of the Madras Corporation.

d) Garbage Collection and Disposal

Madras City generates a daily average of 1500 tonnes of garbage and 1500 tonnes of construction debris. About 30-40% of this waste is uncollected and accumulates in drains and on open land. In addition, there are about 70,000 cattle and buffaloes that contribute to the solid waste problem. Cattle wastes are dumped in the sewers, and result in choking of the sewers.

The Corporation collects about 1000 tonnes of garbage daily using 135 refuse trucks, 700 bullock carts and 6000 conservancy workers. Disposal takes place in low-lying areas without sanitary landfilling, (World Bank 1979).

Present methods of collection and disposal give rise to various problems of environmental sanitation and pollution. The disposal of solid waste in low-lying areas without proper land filling, has the potential of polluting both surface and groundwater. Flies, rodents, and other vectors of disease find these areas to be

convenient breeding grounds. Uncollected waste is thrown on the streets, in stormwater drains or directly into the waterways. After heavy rainfall, a great deal of this waste ends up polluting the waterways. There are also various hazardous solid wastes from medical establishments, from scientific laboratories, and from industries which if disposed improperly might end up polluting the environment.

Thus, the proper management of solid wastes is crucial in terms of reducing the pollution load on both land and water. The Second Madras Urban Development Project financed by the World Bank and the State Government, provided funds to the Madras Corporation for improving solid waste management in Madras City.

Sources of Pollution

Having discussed the inadequacy of urban services to handle the mounting problems of urban wastes, we can now review the four major categories of waste discharges which pollute the waterways.

1. Sewage-Treated and Untreated

The Koyambedu Sewage Treatment Plant (near Arumbakkam) has a treatment capacity of 34 million litres per day. The sewage from the north-west part of the city is treated at this plant filters, and then discharged into the Cooum. The Kodungaiyur Sewage Farm discharges effluent into North Buckingham Canal, which ultimately joins the Cooum. Untreated sewage enters the Cooum primarily through (a) the Stanley via-duct into the Buckingham Canal carrying the wastes of General Hospital, Central Station, Central Jail, PTC etc., (b) the Marina Strip-University of Madras, PWD, Presidency, Queen Mary's College, etc., and (c) overflows from pumping stations.

There are also 27 points along the Cooum where there are overflows of raw sewage, contributing about 20 million litres per day. The Nesapakkam Sewage Treatment Plant discharges treated effluent into the Adyar River.

2. Urban Stormwater Runoff

There are more than a hundred drainage outlets which carry stormwater into the Cooum alone (Narayanan, 1980). The large Nandanam and Mambalam drains discharge in to the Adyar. It is not often recognized that stormwater (particularly, the "first flush") can be highly polluting. Water quality of storm water can be as bad as raw sewage, with heavy metals, etc. (Whipple, 1977). It is reported that many home-owners in Madras illegally connect their sewers to stormwater drains, (Daivamani op.cit). Also, there is a tendency to thrown garbage and other wastes into the drains. While the streets of Madras City are rendered clean by the heavy rains, the street surface contaminants are carried by the stormwater through the drains to the watercourses. These contaminants add to the total pollution loading of all the waterways.

3. Sullage

While some of the sullage enters the waterways through stormwater drains, significant quantity is contributed by squatter settlements on the banks. Due to lack of sanitary facilities, the banks are abused and the nightsoil, domestic wastes-both solid and liquid, and cattle wastes find their way into the water courses. A recent survey by the Madras Metropolitan Development Authority showed that these were about 20475 households on the banks of the three waterways (MMDA, 1988).

4. Industrial Wastes

While some of the industries discharge into the sewer system, there are a few which discharge spent acid wastes, spent lime water, etc., into the Cooum. The North Buckingham Canal Which joins the Cooum has a higher loading of industrial contaminants such as phenols due to discharges from the Manali Industrial Complex. Nammalwar estimates that the Cooum estuary receives 15.4 million gallons/day of domestic sewage, and 0.25 million gallons/day of industrial effluents carrying heavy metallic elements (Nammalwar, 1987). The Adyar estuary also receives large quantities of industrial and domestic wastes.

Measurement of Pollution of the Cooum

There have been numerous studies of pollution of the Cooum and other waterways in Madras City. While it would not be possible to summarise so many varied studies, it might be useful to illustrate the extent of pollution with some examples. While the Cooum is comparatively uncontaminated when it enters the City, it becomes severely polluted by the time it reaches the sea, since it receives a considerable amoung of sewage, sullage and other urban drainage. Since the terrain is very flat, the velocity of flow falls far below the self-cleansing velocity, and silting and sedimentation is heavy (Mohanakrishnan, 1986). The problem is compounded by the sandbar which causes stagnation in the estuarine area. Since a great deal of the pollution is transported to the estuary, it would be useful to review pollution measurements made in the estuarine region. There are also studies of the Adyar and the Buckingham Canal which we will not review here.

Table 3 provide data from five different studies done at different times during the period 1978-85. The earliest study (1978) was conducted six years after the end of the extensive Cooum Improvements Scheme (1967-72). The five-day Biochemical Oxygen Demand $(BOD)_5$, an indicator of organic pollution, was remarkably similar in three of the studies varying from 65 mg/1 to 81 mg/1. Even treated sewage is supposed to meet an effluent limit of 30 mg/1 indicating that the Cooum is more contaminated than treated sewage. The concentrations of total coliform and faecal coliform, indicators of bacteriological contamination, are very high (orders of 10^5 and 10^7 respectively per 100 ml). Faecal coliform considered to be the more reliable indicator, is generally specified at 200/100 ml. i.e., the Cooum has bacterial counts that are more than thousand times the standard. There can, therefore, be very little doubt that the Cooum is grossly polluted by sewage, and specifically by faecal matter. It is an open sewer, and therefore a serious threat to public health.

TABLE 3

Water Quality Measurements at the Cooum River Estuary

Study Year	Studies 1 1978	2 1980	3 1981	4 1985	5 1985	Standard
Parameter						
1. Biochemical Oxygen (Demand (mg/1)	81	27	-	65	77.5	30*
2. Total Coliform (MPN in 100 ml)	--	$92x10^5$	-	$11x10^7$	$130x10^7$	$1x10^3$**
3. Faecal Coliform (MPN in 100ml)	--	$35x10^5$	$13x10^5$ (min) $24x10^7$ (max)	$5x10^5$	--	$2x10^2$**

*Indian Standards Institution-Tolerance Limits for Industrial Effluents Discharged into Inland Surface Waters. IS : 2490 (Part I)-1974.

** Whipple (1977) p.39

Sources: 1. Thanasekharan (1978)

2. Narayanan (1980)

3. Azariah et al., (1982)

4. Kothandaraman et.al., (1986)

5. Venkateswara Rao (1986)

Measurements of dissolved oxygen (DO) at the estuary tend to vary a great deal depending on whether the sand-bar was open or closed. A detailed study on the pattern of DO distribution concludes that, "Oxygen depletion (i.e., a value of zero) is the normal pattern and may occur for long period of time" (Azariah and Dhamodaran, 1986). Some studies indicate little evidence of metallic pollution from industrial wastes. (Narayanan, 1980: Kothandaraman et al., 1986). However, a recent study conducted by Presidency College and published in the Proceedings of the Indian Academy of Sciences, indicates that the Cooum is polluted with heavy metals beyond the toxic limit. Water quality standards for iron, lead, nickel and zinc were exceeded, particularly during the rainy season. Also high levels of phosphates, nitrates and silicates were found, (Anantharaj et al., 1987).

Ecological Impact of Pollution

Physical, chemical and bacteriological indices of pollution, provide individual measurements at different points in time and space, about the magnitude and extent of the problem. Ecological studies on the other hand provide us an integrated picture of the impact that pollution has on the total ecosystem.

Estuaries are considered by biologists to be valuable ecosystems because of their productivity and diversity. The estuary of the Cooum has suffered considerable degradation because of the high level of pollution, which is compounded by the stagnant conditions resulting from the sand-bar blocking the mouth of the Cooum. We briefly review some of the ecological studies conducted by the Zoology Department, University of Madras at the Cooum estuary.

The extent of pollution, particularly in the estuarine area of the Cooum, is so great that it is incapable of supporting fish life (Azariah et al, 1980). Some pollution tolerant species like rotifers and mussels are able to thrive only if the river mouth is kept open. (Narayanan, 1980; Azariah, et al., 1984; Konnur et al., 1986).

A major contribution to the control of pollution in the Cooum resulting from these studies is, " The indication that the culture of Perna Viridis can be a means of abating faecal coliform pollution". Many commercially valuable filter-feeding shellfish such as mussels and oysters are known to ingest and accumulate pathogens besides particulate matter from sewage. It is likely that Perna Viridis (a species of mussels and a pollution tolerant organism) can accumulate sewage derived bacteria, (Azariah et al., 1984). However, the authors warn that there is a health risk of infection through eating such shelfish without proper clearsing. As mentioned earlier, the mussels cannot survive unless there is sufficient dissolved oxygen in the estuary. Thus, it is essential that the river mouth be kept open. This exotic species can then be used for biological purification of the estuary, but not for aquaculture.

Using base-line data from earlier studies, Azariah et al, (1981) have also demonstrated that there has been a drastic change in species diversity in the Cooum estuary. The index of dissimilarity has dropped from 0.9 to 0.5 over a twenty-one year period (1958-1979) due to a reduction in the number of fish species (Azariah et al., 1981). A more recent study on the mangrove eco-system in the estuarine areas of the Cooum and Adyar

rivers, showed a substantial decrease in the species diversity of these ecosystems due to urbanisation. However the authors conclude that, if the mangroves are left alone, they will re-establish themselves, since the soil and other environmental conditions are favourable for their successful colonization, (Azariah et al., 1986).

Conclusion

In this chapter we have reviewed the environmental consequences of rapid urbanisation of Madras City. In particular, we noted the inability of urban services to handle the mounting problem of urban wastes. A major consequence has been the pollution of the waterways. We then reviewed several studies of pollution, which confirmed our hypothesis that sewage and other urban wastes have caused the pollution of the waterways.

Finally, we reviewed studies which show that the estuarine ecosystem of the Cooum has been badly affected. But we also noted that the biological health of the estuarine ecosystem could be partly restored by keeping the mouth of the river open, and by protection of the estuary from further encroachment. There is also possibility of cleansing the estuary biologically using filter-feeding shelfish, if we can ensure adequate dissolved oxygen.

However, it would be preferable to reduce the pollution from various wastes *at the source*. Biological treatement, aeration and other methods of pollution control are desirable only for handling *residual* pollution, but not as the primary means of control. We must also point out that using the sea as a sink for pollutants is *not* a desirable strategy in the long run. Since the

mouth of the Cooum is located very close to Marina Beach, there is a crucial need to avoid contamination of coastal waters which are used for recreation and for fishing. While we may wish to rely on the flushing action of the sea to avoid stagnation and to provide adequate dissoved oxygen in the estuary, it would be most undesirable to consider flushing as the major means of controlling pollution. We will take up these issues for further discussion in later chapters.

Chapter IV

Pollution of the Waterways : Health Impact

Introduction

The rapid growth of human settlements leads to a corresponding increase in the generation of various types of wastes - sewage, sullage, garbage, industrial effluents, etc. Natural processes such as rain, air, sunlight and soil which can degrade wastes in rural areas, are inadequate in urban settlements, where population densities are much higher. Generally, the wastes generated in urban areas trquire treatment and disposal. Improper management can cause various environmental problems, and could lead to the outbreak of diseases.

Thus, measures of health status such as morbidity and mortality are affected by the level of environmental quality. In other words, improvement in environmental factors could in turn lead to a decrease in morbidity and mortality, and thereby improve health status. For example, a study of cholera problems in the Phillippines, concluded that the provision of sanitary facilities for human waste disposal can reduce the incidence of cholera by 68 per cent (Azurin, 1974).

However, it is also known that factors such as nutrition and education have a great bearing on disease rates. Children, and in particular infants are more susceptible to infection if their nutritional status is poor. Slums in urban areas have correspondingly higher rates of infant mortality because of a combination of poor environmental quality, poor nutrition, and low levels of literacy.

Figures 2 shows the linkages between pollution and health. In this chapter, we discuss the pollution problems caused by improper disposal of different types of urban wastes. Next, we look at the major categories of water-related diseases that result from such pollution. Lastly, we provide actual measures of health status in Madras City, with regard to water-related diseases, as an indication of the potential impact of pollution.

Pollution Caused by Improper Waste Disposal

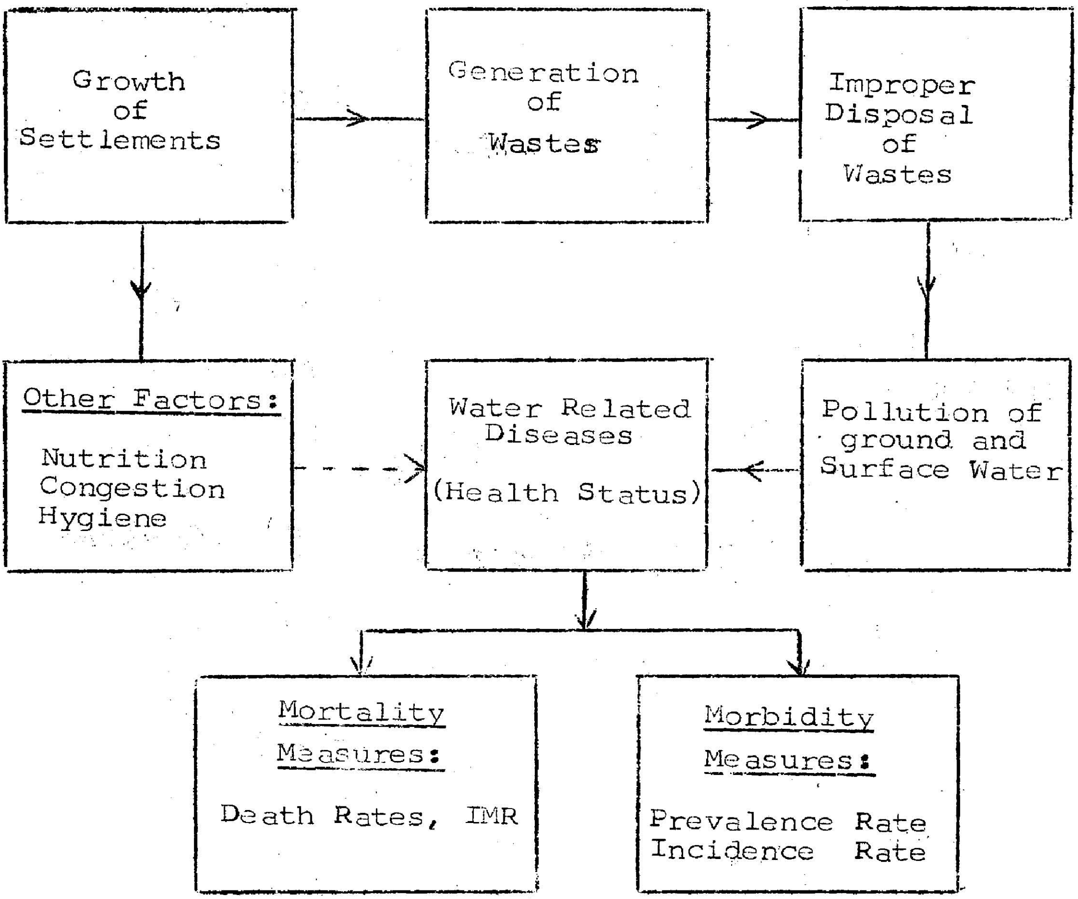
Water bodies such as lakes, rivers and aquifers have a natural capacity to assimilate a certain quantity of wastes. When this limit is exceeded, we refer to the water body as being polluted. The disposal of wastes on land can also result in the pollution of water either by leaching (into the aquifer) or by surface runoff (into a stream or river). When the wastes contain pathogenic material which remain undegraded, the water body becomes a medium for the transmission of disease. The presence of chemicals (inorganic or organic) can also lead to health problems if the water is used for human consumption. The different kinds of urban wastes which pollute the Cooum and other waterways which we discussed in Chapter III have the <u>potential</u> for causing various diseases. These aspects are discussed below.

1. Sewage

About 80% of Madras City is covered by a sewerage management system generating around 240 million litres per day. Flow of sewage and wastewater into the Cooum and other waterways is partly due to inadequate capacity of the sewerage system and, partly from unsewered localities. Generally sewage is pumped through a relay of pumping stations to one of five sewage treatment plants located in the periphery of the City. The effluent from these plants is discharged to the waterways.

Figure 2

Pollution Health Linkage



During sewage treatment, disease-causing organisms may be destroyed or concentrated in the sludges produced; similarly offensive materials may be concentrated in the sludges or biodegraded. As a consequence, the quantities of these agents present in the sewage effluent is much less than in the untreated sewage and their dilution in the receiving waters is far greater (Lester,1983).

In the Madras context, the receiving waters have very little natural flow to assimilate any wastes. So the level of treatment has to be sufficiently high so that the quality of the effluent is equal to or better than of the receiving waters!

If the level of treatment is inadequate, or if raw sewage itself is discharged into the waterways, the potential for disease transmission is very great. These include diseases such as cholera, typhoid, amoebiasis and hepatitis. However, even treated sewage could be a medium for disease transmission. For example, a single cholera carrier may pass 10^{13} (ten trillion) vibrios per day. Where large numbers of organisms are passed, they can give rise to high concentrations in raw sewage, and even in treated sewage (Kalbermatten, et al.,1982). Following treatment disinfection particularly in the case of drinking water, is needed to ensure that the pathogens are eliminated. However, certain categories of pathogens such as viruses are very difficult to control by conventional disinfection, and can be eliminated only at elevated temperatures.

Bacteriological studies of Cooum water have shown elevated levels of coliform bacteria, of E.Coli, and of facecal streptococci (Venkateswara Rao, 1986; Kothandaraman et al 1986). The pollution level of the Cooum is so great that it is indistinguishable from sewage. Even indirect human contact with Cooum water, could be harmful.

There is also the possibility that bacteriological contamination of neighbouring wells could occur. It is absolutely essential that discharge of raw sewage be eliminated, and discharge of treated sewage meet effluent standards.

2. Sullage

All household wastewater other than toilet wastes is known as sullage. Sullage enters the waterways either through storm water drains or through direct discharge by people who live on the banks. Sullage can also contaminate ground water when it is disposed on the premises through soak pits, watering of gardens, etc. Sullage does not have pathogenic levels as high as sewage. However, it must be emphasized that sullage can also cause contamination, if it is not properly disposed.

In addition, stagnant sullage can provide a breeding ground for the *Culex* mosquito, which is a vector of filariasis. The extent to which stagnant sullage can contribute to disease transmission is determined by factors such as soil permeability (Kalbermatten, op.cit). In urban areas where there is a great deal of impervious surface, combined with inadequate drainage, the conditions are conducive for mosquito breeding. This is particularly true in areas of Madras City which have been filled in to provide land for housing. The stormwater drains and the waterways themselves are receptacles for the collection of sullage, and under stagnant conditions become ideal breeding places for *Culex* mosquitoes, and, ultimately for the spread of filariasis.

3. Garbage

Solid wastes or garbage can cause pollution through two different routes. (i) Uncollected garbage is often thrown in the waterways, in stormwater drains, in sewers or on the streets. Most of this waste in one form or another

ends up in the waterways following heavy rainfall.
(ii) Garbage collected by the municipal agencies is generally dumped in low-lying areas as fill material. When sanitary landfilling is not done, these areas provide a breeding ground for disease causing vectors such as flies, rodents and mosquitoes. In addition, the leaching of pollutants into the ground water could also result in contamination.

The improper disposal of hazardous wastes from hospitals, scientific laboratories, etc. pose special problems in urban areas. These require careful management so that they do not contaminate air or water, and thereby cause danger to public health.

4) Industrial wastes

There are a wide variety of industrial wastes which end up in the waterways. According to Metrowaters there are no major industries discharging effluent into the Madras sewerage system. (World Bank, 1987) Presumably, all the major industries are discharging their liquid wastes, with or without treatment either into water bodies or on land. As mentioned earlier, wastes discharged on land always have the potential of polluting ground water. The regulation of the discharge of effluents is done by the Pollution Control Board. Metallic and non-metallic (inorganic and organic) pollutants can have various health effects. These effects are too numerous to list here. In general, they include acute and chronic toxicity, teratogenicity, mutagenicity and carcinogenicity. Water standards have been developed by the World Health Organisation and the Indian Standards Institution largely to protect the public from pollutants causing chronic and acute toxitity such as heavy metals, sulphates, nitrates, cyanide, etc. The

other effects are not well established, although some attempts have been made to set standards for organic compounds which are either known or suspected to be mutagens or carcinogens.

Studies of the waterways in Madras City have indicated high concentrations of certain heavy metals like iron, lead, nickel and zinc which are contributed by various plating and metal processing industries. But there is no indication that these are as yet entering the food chain or affecting drinking water supplies. More data are needed. A study of drinking water quality at various points in the water distribution system found <u>marginally</u> high values of trihalomethanes. The concentration levels slightly exceeded American standards, but were well below standards in some European countries (Azariah, 1987). The concern about trihalomethane stems from the fact that some of them like chloroform are known to be carcinogens. However, the major cause of the existence of the trihalomethanes, is the cholorination done for disinfection. We, therefore, have the interesting situation where cholorination, which decreases the health risks caused by pathogenic organisms, could in turn increase the risk of getting cancer by ingesting trihalomethanes over a long period. Most specialists, however, feel that disinfection efficiency must not be sacrified under any circumstances, even if chlorination leads to the formation of trihalomethanes, (Packham, 1983). Improper disposal of industrial wastes can contaminate ground water supplies. The discharge of industrial effluents on land or in lagoons can contaminate neighbouring wells. Dumping of industrial solid wastes into low lying areas without sanitary landfilling can result in the leaching of pollutants in to the aquifers. Thus, the population relying on wells

for most of their water could potentially be affected. Some research has been undertaken in this direction by the Centre for Water Resources, Anna University, but we do not have adequate empirical evidence to draw definitive conclusions as yet.

Diseases caused by water pollution

In the previous section we explored the linkage between waste disposal and water pollution. We discussed how different types of urban wastes - sewage, sullage, garbage and industrial effluents - can pollute the water, and ultimately cause health problems. In this section, we will take the discussion one step further by discussing the specific types of diseases that result from water pollution. We will also briefly examine the factors that contribute to the spreading of water-related diseases.

Water-related diseases can be grouped under the following four categories (Saunders and Warford, 1976).

1. Water borne diseases: Water acts only as a passive vehicle for the infecting agent. All these diseases are related to poor sanitation. These diseases include cholera, typhoid, amoebiasis and infectious hepatitis (The latter two could also be classified as waterwashed).

2. Water washed diseases: Lack of water and poor personal hygiene create conditions favourable for their spread. The infections in this group also depend on lack of proper human waste disposal. This group of diseases include scabies, skinsepsis, leprosy, trachoma, conjunctivitus, dysentery, enterovirus diarrohoeas, hookworm, etc.

3. Diseases caused by water related vectors: Infections are spread by insects that breed in water. Generally unaffected by waste disposal (other than sullage), these diseases include dengue fever, encephalitis, bancroftian filariasis, malaria, etc. It must be mentioned, however

that the Anopheles mosquito which is a carrier for malaria, does not breed in polluted water.

4. Dieases caused by Chemical Contaminants in Water

A fourth category of diseases relates to the presence of various chemicals in water. There are tens of thousands of inorganic and organic compounds which are actually or potentially toxic. Some have acute short-term effects, while many others have chronic effects due to long-term, low-level exposure. However, these effects arise only if the contaminated water is used for human consumption, either for drinking or through the food chain (fish, milk, etc.)

In the remainder of this discussion, we will focus our attention, largely on the first three categories of diseases - waterborne, waterwashed, and diseases caused by water - related vectors. We will not discuss the diseases caused by industrial and chemical pollution, because there is very little data from epidemiological or toxicological studies done in the Madras context. This is not to say that these concerns are unimportant. We simply cannot comment on this issue in the absence of reliable data.

The control of diseases of the first three types requires ample quantities of safe water, good hygiene, and proper disposal of wastes. In an urban area like Madras City, where population densities are high, inadequate disposal of human wastes, sullage and garbage, provide the ideal conditions for the spread of various diseases. The hot, humid climate also aids the multiplication of disease - producing organisms. It is not surprising, therefore, that diseases such as cholera, typhoid, gastro-enteritis, filariasis, malaria, hepatitis and other diseases are prevalent in Madras City, particularly in the congested areas, where population densities exceed 100,000 persons per sq.km. We will discuss this data in detail later.

The need to improve the quantity of water available is often more important than the need to improve its quality for various reasons. Water that is adequate for personal and household cleansing does not need to meet the safety standards of water for drinking and cooking (World Bank, 1980). In the context of disease incidence, some studies have shown that certain infections caused by waterwashed organisms, respond to quantity of water used for personal hygiene, and not so much to the quality of water consumed for drinking. (Feachem, 1978) Thus, precautions such as boiling may be insufficient to prevent certain types of diseases, if the basic problem is inadequate quantity of water.

In his study of infant mortality in Tamilnadu, Nagaraj observes that urban (and rural) infant mortality rates are much higher than Kerala irrespective of the source of drinking water. He concludes that 'factors other than access to drinking water from taps and hand pumps (which are presumably disinfected) have a crucial bearing on infant mortality'. Given the abundance of water in Kerala when compared to Tamilnadu, the availablility of adequate quantity of water and better hygiene are probably more significant in terms of lowered infant mortality rates. (Nagaraj,1986).

Madras City provides a per capita supply of around 78 litres per day, the lowest for any urban area in India and for different socio-economic groups is highly skewed. Slum families depend on public taps. It is estimated that 175 persons on the average have to depend on a single tap (Guhan,1981). During the recent drought (1986-87) conditions were much worse. Thus, the quantity of water available is grossly inadequate for personal hygiene and to arrest the spread of water-washed diseases, although the quality of water meets WHO standards.

Thus, inadequate quantity of water coupled with poor hygiene and congestion contribute to the spread of several water-related diseases in Madras City.

In this section, we have discussed the various categories of water related diseases caused by pollution, and also other factors (such as quantity of water and personal hygiene) which promote the spreading of certain diseases. We also made reference to the specific environmental conditions in Madras City which are conducive to the spread of water related diseases. In the next section, we will examine measures of health status such as mortality and morbidity to get a clearer picture of the health impact of inadequate waste disposal in Madras City

Measures of Health Status

The two commonly used measures of health status are mortality and morbidity. Mortality can be measured in terms of crude death rate, infant mortality rate, and if the data is available, age/sex specific death rates. However, for our purposes, the infant mortality rate (IMR) is of interest, because it is "distinctly higher in the case of populations living in poor environmental conditions such as slum areas." (MIDS,1988)

Morbidity refers to the prevalence or incidence of water related diseases such as cholera, gastro-enteritis, hepatitis, filariasis, malaria, etc. Due to some confusion in terminology, we will first define the terms prevalence and incidence. Prevalence is the fraction of the population infected with a particular disease at any point in time. Incidence in a given population is the proportion of infected and uninfected individuals over a period of time.

The objective of policy makers is generally to reduce the existing <u>prevalence</u> of water-related or other diseases. Therefore, we will focus our attention on the existing prevalence of the above mentioned diseases.

Before we proceed to a discussion of the data we must explain why mortality and morbidity are important measures of health status from a social perspective. When a person (or infant) dies prematurely, society loses the output which he/she would have produced over an extended lifetime. (Saunders and Warford 1976). There have been a lot of debates about how the economic loss should be computed, and, whether it is even ethical to place a valuation on human life (Russell, 1986).

The effect of a reduction in morbidity would be to improve output in a number of different ways:

a. treatment costs averted
b. reduced worker absentee rates
c. improved worker productivity
d. less earnings loss by other members who provide care.

In the developing country context where resources (financial, medical personnel and supplies) are scarce, it is far more economical to prevent disease. When compared to providing treatment. The other aspects are also important in terms of improving labour productivity.

These measures of economic costs do not include the emotional and social damage resulting from debilitating illnesses like cholera and hepatitis. In estimating the costs and benefits of pollution control, it is difficult to put a <u>financial valuation</u> on the health benefits of reduced mortality and morbidity. We cannot document with any assurance, the actual reduction in the number of cases of a particular disease, say cholera from improvements in santiation. The task would be somewhat ambitious at a citywide level where there are a

number of intervening variables. If a clean-up project is undertaken, we might be able to perform evaluation studies in selected areas to determine the extent of health impact. Such detailed studies of health impact of pollution are clearly needed in Madras City. For the present, we will merely discuss the existing situation in terms of mortality and morbidity measures, without quantifying the benefits of improvements in health status.

Infant Mortality Rate in Madras City

The study of infant mortality rates in Tamil Nadu cited earlier, indicated that the IMR in Madras City between 1971-76 was around 80 deaths per thousand of population. The IMR in Madras City which has some of the best hospitals in the State and possibly in the country, is slightly higher than the figure for urban Tamil Nadu (of 75), and not very different from urban India (82) (Nagaraj, op.cit). By 1983, the IMR in urban Tamilnadu (and presumably Madras City) had dropped to 57 which was not appreciably different from the urban India figure of 64. However, this figure was worse than twice the level recorded in urban Kerala of 27. (MIDS, op.cit.)

We must also point out that the IMR in slum areas of Madras city was 70% higher than in non-slum areas according to a census report in 1961. As Nagaraj points out, "Given that there has hardly been any improvement in the level of basic amenities, these conditions would have worsened (since 1961) with an increasing level of congestion in the slums in the City" (Nagaraj, op.cit).

Among the major causes of infant mortality are water-related diseases such as diarrhoea, typhoid and jaundice (hepatitis). The combined effects of malnutrition and infection are often critical, as mentioned earlier (MIDS, op.cit). Since the water-related diseases are caused by inadequate waste disposal, there is a link between pollution and health status. Thus, environmental improvements in terms of improved sanitation could potentially lead to a decrease in these water-related diseases, and ultimately to a lower infant mortality rate, particularly if such improvements are coupled with improvements in nutrition and personal hygiene.

However, the relationship between infant mortality rates and environmental pollution is somewhat tenuous because of other confounding variables. The link between environmental pollution and morbidity rates for water-related diseases is somewhat more apparent in the Madras City context.

Morbidity Rates in Madras City

a) Cholera and Gastro-Enteritis: Table 4 provides the number of notified case of cholera and gastroenteric disease for Madras City from 1972-1986. The data shows an average of 1650 cases per year of cholera over the period.

TABLE 4

Notified Yearly Cases of Cholera and Gastro-enteritis in Madras City (1972-1986)

Year	Cholera	Gastro-enteritis
1972	2275	3256
1973	1722	3153
1974	2869	3371
1975	1389	4386
1976	295	2537
1977	1262	2729
1978	2205	3029
1979	871	2299
1980	2663	2119
1981	1236	2155
1982	2024	1965
1983	2502	2302
1984	519	1429
1985	1862	2062
1986	1120	1365

Source: Health Officer, Corporation of Madras.

A study of the geographic distribution of cholera incidence in Tamilnadu for the period 1961-74 concluded that, "Madras City has been reporting year-round cases of cholera, thereby indicating an increase in urban incidence, increasing with the rates of urbanisation" (Hyma and Ramesh, 1976).

In order to assess the impact of pollution caused by inadequate waste disposal, it was decided that a small study be undertaken of the prevalence of cholera in Madras City. The M.A. Chidambaram Institute of Community Health had obtained in-patient data from the Communicable Diseases Hospital, Tondiarpet with regard to cases of cholera and gastro-enteric diseases for the period 1974-78.

The number of cases of cholera and gastro-enteric disease in each division were counted for two of the years - 1976 (a low year for cholera) and 1978 (a relatively high year and the most recent). The population in each division was obtained from 1971 census data. The mean prevalence of cholera for the two years was calculated, and was found to be 0.1 (in 1976) and 0.88 (in 1978) cases per thousand of population per year. It was also noted that the prevalence of cholera was much higher during the latter half of the year (Table 5).

TABLE 5

Monthly Cases of Cholera (1976, 1978)

Month	1976 cases	%	1978 cases	%
January	28	11.3	51	2.4
February	12	4.8	71	3.3
March	8	3.2	14	0.7
April	3	1.2	8	0.4
May	-	0.0	9	0.4
June	3	1.2	6	0.3
July	3	1.2	23	1.1
August	10	4.0	106	4.9
September	16	6.4	921	42.5
October	41	16.5	389	18.4
November	19	7.6	322	14.9
December	106	42.6	238	11.0
Total	249	100%	2168	100%

Source: In-patient Records, Communicable Diseases Hospital, Tondiarpet

% cases July-December 1976: 78.3%
1978: 92.8%

8 out of 120 divisions in Madras City reported more than 3 cases per 1000. 3 of these 8 divisions reported more than 4 cases per 1000. All the three divisions (Choolai, Triplicane and Vyasarpadi) are proximate either to the Cooum or the Buckingham Canal. The first two are also congested with a population density exceeding 100,000 people per sq.km.

Vyasarpadi also had a prevalence rate of greater than 4 cases per 1000 of gastro enteritis. In 1976, the number of notified cases of cholera was unusually low (295), and, prevalence rates were less than 1 per 1000 in all divisions of the City.

The severity of the cholera problem can be better understood if we compare the number of reported cases of cholera in Madras with state-wide and nation-wide data. In 1983, Madras City reported 2502 cases of cholera, compared to 3252 for Tamilnadu and 8542 cases for India as a whole. In other words, Madras City accounted for 77% of cholera cases in the State, and for a staggering 38% of cases in the entire nation. It would not be an exaggeration to say that cholera in endemic in Madras City. Since it is well known that cholera is caused by inadequate sanitation, there is little doubt where investment priorities should lie. Particular care must be taken to arrest the spread of cholera during the monsoon season. It is during this period that water supply lines, wells, and other sources of drinking water get contaminated with sewage.

b) Hepatitis

A temporal and spatial study of infectious hepatitis in Madras by Vasantha Kumaran for the period 1971-78, indicated that the prevalence of hepatitis was about 1 case per thousand for the entire period (Table 6). The yearly totals of reported cases varied from 340 to 621 cases i.e. an order of magnitude smaller than cholera. The number of cases also tend to reach a peak during the latter half of the year, when there is more rain. A major conclusion of the study was that children are more susceptible to hepatitis than adults. The diffusion of hepatitis cases started from the north and north-east and over the years moved southwards covering new areas, but intensifying in the core areas, (Vasanthakumaran and Ananthan, 1986).

TABLE 6

Cases of Hepatitis in Madras City
1971-1978

Year	Yearly Total
1971	326
1972	593
1973	417
1974	340
1975	621
1976	359
1977	500
1978	455
Total Cases	3611

Sou.ce: Vasanthakumaran and Ananthan (1986)

c) Filariasis

Another water-related disease that is of concern in Madras City is bancroftian filariasis. The Culex Fatigans mosquito which is the vector that spreads filariasis breeds in polluted water. It proliferates in and around human settlements, and, is closely associated with man, (Rajagopalan 1986). Inadequate sewerage and drainage facilities provide a breeding place for this species of mosquito.

The Corporation of Madras has been implementing a Filariasis Control Programme in areas of the City which are known to have high incidence of the disease. Blood smears are collected from individuals on a house-to-house basis and tested. Over the last six years, 410,800 smears (i.e., more than 12% of the

1981 population of Madras City of 3.28 million) have been collected and tested. As shown in Table 7 9236 tested positive for micro filaria and 2266 tested positive for the disease. i.e, a micro-filarial rate of 2.25% and a prevalence rate of 0.55%.

TABLE 7

Incidence of Filariasis-Parasitological Data

Year	No.of Blood smears collected	No.Positive for micro-filaria	Micro-filarial rate(%)	No.Positive for disease	Disease Rate (%)
1980	43,834	1,926	4.40	203	0.46
1981	44,892	1,768	3.94	227	0.51
1982	63,581	1,639	2.58	396	0.62
1983	68,332	1,375	2.01	402	0.59
1984	87,567	987	1.13	444	0.51
1985	102,594	1,541	1.50	594	0.58
Total	410,800	9,236	2.25	2266	0.55

Source: Health Officer, Corporation of Madras.

d) Malaria

During the period 1975-85, around 40,000 cases of malaria have been reported every year in Madras City. Almost the same number was reported in 1986. This works out to a prevalence rate of more than 10 per 1000 of population. Malaria cases are reported throughout the year but the rate is higher during the rainy months.

A divisionwise analysis done by the Corporation of Madras for 1985 showed that there were cases of malaria in every one of the 150 divisions. Only 26 divisions reported less than 2 cases per 1000 (Corporation of Madras, 1986). The highest rates were reported in Sowcarpet, Elephant Gate, Seven Wells, Vallalarnagar, Edapalayam, Perumal Koil Garden Adikesavapuram and Chintadripet. Most of these divisions are proximate to the Buckingham Canal or the Cooum. The latter two are located in the last loop of the Cooum. Most of these areas are congested, older areas of the City.

We have reviewed the available data on the prevalence of major water-related diseases in Madras City. We can get an overview of the situation by looking at the prevalence rates in 1985 (except for hepatitis for which we use 1978 data.

No.	Disease	No.of Notified cases	Prevalence Rate (cases/1000)
1.	Cholera	1862	0.57
2.	Gastro-enteritis	2062	0.63
3.	Hepatitis (1978)	455	0.18
4.	Filariasis	2135	0.65
5.	Malaria	51,256	15.64

We must also keep in mind that the number of notified cases is an underestimate. Even though cholera and malaria are notifiable diseases, many private doctors do not notify the public health authorities.

Thus, it is very clear that all these water-related diseases were widely prevalent in Madras City as late as 1985, and occur in parts of the City that are proximate to the Cooum or Buckingham Canal. However, it is not the case that all divisions proximate to the waterways have high rates. Only some of the divisions close to the estuary and/or areas which are extremely -ted seem to exhibit high prevalence rates.

We must also note that slum areas are scattered all over the City. Many of the slums have inadequate waste disposal, both for human wastes and for garbage. The possibility of pollution of surface and ground water and the potential for disease is much greater in their immediate vicinity. In fact, there are a large number of slum households who live on the banks of the Cooum and the Buckingham Canal. We do not have sufficient micro-level data to determine if the prevalence of water-related diseases is higher in these slum areas. Division level data can only give us an indication of population densities, and, therefore the extent of congestion. Many of these congested areas are mainly older built up areas like Triplicane, Chintadripet, Sowcarpet, etc., and, may not have settlements of huts as seen in South and West Madras. We need further studies of health status in slums to draw firm conclusions.

Although it has been difficult to attribute the prevalence of all these diseases (cholera, hepatitis, filariasis) to environmental pollution in a statistical sense, there is substantial evidence that these water-related diseases continue to be of major concern in Madras City. There is, therefore, an urgent need to improve environmental sanitation in human settlements, particularly the reduction of wastes which end up polluting the waterways.

Conclusion

The purpose of this chapter was to demonstrate that there are health benefits which might result from not discharging wastes into the waterways. We are not suggesting that the prevalence of water-borne diseases

will drop dramatically when the discharge of the wastes is reduced or eliminated. The relationship between health status measures and level of sanitation is not necessarily linear. As mentioned earlier, there are other factors which also affect health status. But, we are suggesting, that proper waste disposal should be one element in a "package" of services that will improve public he lth. Some researchers suggest that beyond some threshold level of socio-economic status, water and sanitation improvements do make a significant difference in health status, (Shuval et al, 1979). There are, therefore, significant health benefits in the long-term.

Since the relationship between pollution control and health is complex (and is not as transparent as one might think from the popular press!), we felt it would be worthwhile to devote an entire chapter to the subject. In the context of this report, health benefit is only one of several categories of benefit, that result from cleaning up the Cooum and other w.terways. In other words, it is not necessary to provide demonstrable proof of health benefit, to justify a clean-up programme.

On the other hand, we must note that the prevalence of various water-borne diseases such as cholera, hepatitis, filariasis, malaria, etc. in Madras City is already a matter of considerable concern. Proper collection and disposal of wastes should be considered as one element in a multi-pronged strategy to reduce the prevalence of these diseases. The full impact of this effort may be felt only in the future. Its value lies in stemming the gradual deterioration of the environment, which might reach alarming levels of prevalence if no action is taken at the present time.

Cleaning up the waterways addresses this problem partially. In a cost-benefit equation for pollution control, we can chalk up some benefits to public health as part of our computation of total benefits, which includes improvement to the ecosystem, visual quality, recreation, tourism and so on. But, we should also consider other policy options, such as increasing the per capita supply of water, providing better housing, and better nutrition, if we wish to see any dramatic improvement in public health.

SECTION B

PLANNING FOR THE WATERWAYS;

METHODOLOGY AND APPRAISAL

Chapter V

The Rationale for Pollution Control

In Section A, we have documented the extent of pollution of the waterways, the diverse sources of that cause the problem, and the ecological and health impact of such pollution. While there is little doubt about the severity of the problem and its consequences, the role of the planner is to determine what should be done about it, who should do it, and who should pay for it. Specifically, should the Government intervene in such a situation, and undertake a major clean-up programme? If it does, what should be the focus of the programme and the appropriate level of investment? Should private individuals/organisations who contribute to the pollution bear some of the costs? The answers to these questions are not self-evident and involve a fair degree of analysis. We begin by considering the peculiar characteristics of environmental pollution, which provide some clues for the design of remedial programmes. In this chapter, we will use these concepts to develop a rationale for pollution control. In the next chapter we will outline a methodology for water quality maangement that can actually be used in Madras.

There are two major characteristics of environmental resources that provide the basis for government intervention in pollution control. The first is the "externality" aspect of pollution, and, the second is the "public good" aspect. We will discuss each of these with regard to the waterways.

The Externality Approach

When an individual or firm pollutes the environment by discharging wastes, he causes damage to human, animal and plant life. By not controlling his pollution, the polluter "externalizes" his costs. In other words,

he causes others in society to bear the costs of his actions. Thus a government which is concerned about societal costs can through regulation, taxation or other policy instruments force the polluter to "internalize" his costs. If the cost of pollution control is very large, and the product or service provided by the polluter is deemed to be in the interest of society, the government may choose to subsidize the cost by a variety of ways, including publicly -owned waste treatment facilities.

However, if the government chooses to do nothing, there is no mechanism within the market system, to alleviate the problem. The only other solution is for the victim(s) of pollution to either sue or negotiate with the polluter to abate (control)pollution. In the case of urban pollution, where there are many diverse sources it is unlikely that this solution will work. When pollution is caused by municipal agencies themselves, there is an added complication. In this sort of situation, it is advisable for government to intervene, and force all identifiable polluters to stop discharging wastes into the waterways. Such an action imposes restrictions on the polluters, and forces them to "internalize" their costs. These sources include industrial establishments, municipal sewage treatment plants, and the like. It also includes owners of houses and commercial establishments who discharge their sewage into stormwater drains and who must be forced to pay for a sewer connection. The more difficult cases are those of small workshops and poor households who live on or near the banks. There is some justification for the government to either subsidize their costs or provide public facitlities to take care of their pollution.

Thus, the externality argument has been widely used to justify government intervention in environmental management. Economists have concerned themselves with the "efficiency" aspects of such intervention, and in devising an optimal strategy for pollution control (Baumol and Oates, 1974; Dasgupta, 1982; Fisher, 1981; Kneese and Schultz, 1975). However, in a situation where there are many diverse sources, and where regulations already exist, the concern for efficiency is at best academic. We shall not pursue this theoretical line of enquiry in this report, except in very general terms.

The Public Good Approach.

In the case of environmental resources such as air or water, it is difficult to hold any single agent responsible for pollution. It is also difficult to identify any individual whose well-being is solely affected by pollution, although we do know that there are many groups who could potentially be affected. There are clearly social damages caused by pollution, which could be reduced by proper pollution control measures. In other words, the agents causing the pollution may also be the agents whose well-being is affected by it; although different groups, particularly the poor, may be disproportionately affected. Thus, the costs of reducing pollution will have to be borne by the public, directly or indirectly.

Similarly, the benefits of pollution control accrue to the public at large. The health, ecological, recreational and other benefits accrue to society, and individuals cannot be excluded from those benefits. There may of course be individuals who benefit disproportionately such as those who own land near the waterways, who may experience an increase in land value. We will take up such distributional issues in a later section. But by and large, a clean environment is a "public good".

Public goods are defined as goods which have to be made available to all, once they are produced. Pure public goods, by definition, cannot be provided by the market. Provision of public goods is a classic case for government intervention. Thus, providing a clean environment in Madras by cleaning up the waterways, is and should be the function of government.

So far, we have argued that pollution control is a legitimate function of government because:

(a) pollution is a negative externality which the market cannot correct, and,

(b) a clean environment is a public good which the market cannot provide.

However, determining the level and nature of government intervention is complex because we must have a method of valuation for the services to be provided. Available conceptual and empirical methods for placing monetary values on non-market goods and services such as clean water are imperfect. We will discuss some of these methodological limitations, since they have a bearing on environmental policy. These include:

a. difficulties in measuring output
b. the problem of the "free rider "
c. over-exploitation of the resource.

We will discuss each of these issues briefly.

As is the case with many non-market goods it is difficult to measure the demand for clean water. There are many possible measures of water quality such as the level of dissolved oxygen. But, we also need to know the consumers' willingness to-pay for different levels of water quality. The presumption is that this aggregate demand curve is downward sloping. However, tese are only theoretical postulations, and are difficult to estimate for empirical work.

Some economists like Tiebout have suggested that the location preference of individuals reflects in part their valuation of public goods (Tiebout, 1956). Individuals who wish high quality services live in communities which are highly taxed and where rents are high. Those who prefer not to receive such benefits live elsewhere. In a Tiebout world, the poor can be expected to occupy the less attractive parts of the metropolitan area for lower rents. However, if different income groups have the freedom to segregate themselves geographically according to the level of environmental quality, their environmental quality is no longer a pure public good (Baumol and Oates, 1975).

In the Madras context, this is partly true of the poor who live on the river and canal banks paying little or no rent, subjecting themselves to health and flood hazards (i.e. a low level of environmental quality). However, both the rich and the poor are affected by pollution of the waterways. To this extent, clean water can be considered a public good, but not a pure public good.

A similar approach has been used in the environmental literature, using residential property values as a surrogate for the level of cleanliness (in terms of air or water pollution) of the area. However, we need more empirical studies in Madras and other Indian cities.

The problem of the "free rider" arises with regard to the question of payment for the public good. The typical solution has been general taxation, so that all those who enjoy a publicly provided good, pay for it through the tax system. In a society where only a small percentage pay taxes, there may be many "free riders". However, it must be pointed out that even the poor pay sales taxes, which form part of the revenue base through which public goods are provided. Thus, without a careful

analysis of tax incidence, it would be difficult to say if there are any "free riders" with regard to specific public goods.

Finally, public goods which are "common property" resources tend to be over-exploited. (We use the term "common property" in the sense of free access). The most frequently cited article in this regard is Hardin's "Tragedy of the Commons". In the absence of community regulation, a common property resource like a pasture (or commons) will be over-utilized by individual farmers who seek to maximize their own welfare. While some theoretical objections have been raised against Hardin's formulation (Runge, 1986; Dasgupta, 1982), there is little doubt that a situation like the pollution of the waterways is a result of over-use, as a convenient sink for dumping wastes. However, as a common property resource, it is very difficult to regulate every single discharger. In the absence of cooperation among users of the common property resource there are losses. We have to identify what these losses are and who bears them (Dasgupta, op.cit) It is inevitable that some form of a collective approach be used.

While accepting that there are severe limitations in using economic analysis for environmental policy because of problems of valuation, it is nevertheless useful to discuss the benefits and costs of government intervention atleast from a qualitative perspective

Benefits of Pollution Control.

We can classify benefits in the following categories:

a. Health related benefits

b. Visual quality-including recreation and tourism potential

c. Aquatic ecosystem effects
d. Water supply and other forms of reuse.

We will discuss each of these aspects briefly.

a) Health Benefits

When domestic sewage and other wastes are dumped into an urban waterway like the Cooum River, there is a potential threat to public health, particularly for those living in the vicinity. There are a number of diseases that are water-borne or transported through water by vectors. Some of these diseases include cholera, gastro-enteritis, hepatitis, filariasis, various skin diseases, etc. The diseases can be transmitted through sewage and/or through vectors like mosquitoes, flies, and worms.

When the level of pollution is reduced, the potential for transmission is also reduced. Health benefits can be expressed in terms of reduced morbidity and mortality, decreased cost of treatment, and increased productivity. However, establishing cause-effect is not easy because of many confounding variables such as personal hygiene, congestion, availability of protected water supply, and so on. But, there are significant health benefits in controlling pollution from sewage and urban wastes, as discussed in Chapter IV.

b) Visual Quality

The pollution of the Cooum is so severe that it is easily perceived and understood by the average person. The obnoxious odour during the dry season has been well documented. (Srinivasachari, 1939). Individuals are likely to be in favour of cleaning up the Cooum to improve visual quality. We turn to this discussion of public perception later.

There would also be incentive to develop land adjacent to the river for parks and other public uses. Private residential and commercial property values are bound to rise. The river itself could be used for boating, and, for enhancing tourism. The boating piers that were built during the 1968-72 improvement project remain unused, because the Cooum remains too polluted for boating and other recreational activities. Since the Cooum flows through the central part of the City, it could be widely used to transport tourists in a pleasant and convenient manner.

c) Aquatic Ecosystem Effects.

The estuary of a river is a particularly valuable ecosystem, since it provides food and shelter for many important species of fish. The marshes and wetlands themselves perform a useful function in absorbing pollutants, and converting them into biologically usable and harmless forms, (Whipple, 1979). The mangrove ecosystem is a charateristic feature of many tropical coastal areas, including coastal Tamilnadu. All the estuaries near Madras (including the Cooum estuary) had mangrove forests in the vicinity. Pollution and increasing urbanisation have depleted the mangroves and the associated ecosystems as explained in Chapter III.

The species diversity of the mangrove ecosystem has been reduced considerably by pollution. However, it is felt that this is not an irreversible phenomenon. The mangroves can reestablish themselves since the soil and environmental conditions are favourable for colonization, (Azariah et al., 1986). Thus, control of pollution of the waterways and, proper maintenance of the adjacent wetlands can have a substantial positive impact on the aquatic ecosystem. But, expressing this impact in monetary terms is even more difficult than is the case with health impact.

d) Water Supply and Other Uses of Wastewater:

Pollution of the river can cause some damage to the quality of water in adjacent wells, particularly during times of drought, (Venkateswara Rao, 1986). More significantly, the wastewater which is currently dumped into the waterways could be a valuable resource if it were treated. The nutrients in the wastewater could be used for growing fodder or for producing biogas. The treated effluent could be used for industrial purposes, or for parks, or for maintenance of minimum flows during the dry season. The present system represents a waste of resources that could be recouped by proper management. There are, therefore, economic benefits in reusing wastewater by proper collection and treatment, which in turn reduces the pollution of the waterways.

From a theoretical standpoint, the pollution of the waterways has major opportunity costs. The benefits of clean water in terms of health, visual quality, the aquatic eco-system, and other potential uses are lost, by dumping wastes into it. The benefits of clean water will not be available if there is no public control of pollution. As a public good, there is no choice but to assign public responsibility for the maintenance of a clean river. Public agencies have to use public funds to make the resource available to everyone, so that all segments of the population can benefit from it.

The Costs of Pollution Control

A detailed consideration of costs requires a discussion of pollution control technology, which we will reserve for the next chapter. However, at this point it would be useful to make three general observations.

1) In an urban context, there are many sources of pollution. (We have discussed these in some detail in Chapter III). In the case of large identifiable sources, it is technically and economically possible to require them to diminish or stop the effluents that they are discharging. In the case of many small, diffuse sources a collective approach may have to be used if it is feasible. Yet another approach is to allow some of these sources to discharge into the waterways, and then treat the waterways themselves. Clearly, the costs will vary depending on the technological options chosen.

2) Water like many environmental resources, exhibits "threshold" effects. A river or stream has a natural capacity to assimilate wastes uptil a certain threshold level. It can sustain a fairly complex eco-system until this level is reached. When the river is totally free of pollution, the diversity of species is generally large. As pollution levels increase, only the hardier species survive. Beyond the threshold, there is little or no dissolved oxygen for plant or animal life, and the river is considered to be "biologically dead". After this point, if pollution loading is increased, the river gradually becomes an open sewer, which is the case with the Cooum. Thus, when we control pollution in a severely degraded watercourse, the primary objective is to atleast bring down the level of pollution below the threshold, so that living organisms can thrive. This effort must be done in a cost-effective manner by evaluating various options (Dasgupta, op.cit.)

3) However, the costs of control tend to escalate when we seek higher and higher levels of purity. The cost of cleaning the final 5% of pollution is often equal to cleaning the first 95% (Kneese and Schultz 1975). Thus, it is important to set our water quality goals in a realistic manner. We will pick up this discussion of setting goals in Chapter VI.

In the specific case of the Madras waterways, pollution is caused by four major categories of sources-industrial wastes, sewage (treated and untreated), stormwater, and sullage/garbage. Pollution control implies reductions in each of the categories, individually or collectively.

a) Most major industries which discharge directly or indirectly into the waterways, come under the purview of the Pollution Control Board. Effluent standards are enforced by the Board, and the industry has to comply within a certain time-frame. Smaller industries can also be regulated by the Board as it sees fit. The cost of control in all these cases is borne by the polluter, unless there is evidence of serious financial impact. Some tanneries, for example have argued that the financial burden of meeting pollution control regulations is beyond their capacity.

b) Municipal wastewater plants are also regulated by the Board and have to meet effluent standards. If they are out of compliance they have to expend resources to suitably upgrade their facilities. Unsewered areas need to be provided with sewer services. Some of these costs are financed through the water and sewer tax. Capital costs may have to be financed by non-local sources

c) Stormwater-If any treatment is provided, the cost will be met by the Madras Corporation. The illegal discharge of sewage into stormwater drains can be controlled by forcing the homeowner/commercial establishment to pay for the sewer hook-up, and, the regular water and sewer tax.

d) Sullage/garbage-can be controlled by providing on-site sanitation and waste disposal facilities. These

costs will generally be paid by the Corporation, which may recover a small portion through the property-tax and/or user charges (pay-and-use toilets). In cases where relocation is needed, the costs of relocation may have to be met by the Government. We will discuss this later in some detail.

Where it is not feasible to control pollution at the source, it may be possible to purify the river after pollution has entered it, by a number of different way. These collective measures include:

a) Maintaining flow conditions by removing the sand-bar at the mouth by dredging, building a breakwater, etc.

b) Maintaining flow conditions by augmenting flow in the river.

c) Aeration of the river mechanically, or through weirs.

d) Biological treatment of the estuary using filter-feeders.

These options could be implemented individually or in combination. Each option has associated costs, and, trade-offs are possible by substituting one element for another to reduce overall costs, (Kneese, 1965). Consequently, a detailed technical appraisal has to be conducted to estimate these costs.

Financing Pollution Control

Assuming that a detailed technical appraisal is conducted by the relevant agencies, it will be necessary to finance the public investments that are needed, such as upgrading sewage treatment plants, extending sewer services, collecting and treating stormwater, building sanitation facilities, and making improvements to the waterways themselves.

Since local resources are relatively inelastic (due to the poor collection of property taxes which constitute 80% of the revenues of the Madras Corporation), the only means of financing such a programme is by obtaining funds from the Central and State Governments or from international agencies. It is unlikely that user charges (water and sewer tax) will even cover the operacing cost. The financing of the programme raises two separate questions, namely, the progressivity of the tax structure, and, the matter of "spill-overs".

Tax systems at the Central, State and local levels have different levels of progressivity. The Central tax system is probably the most progressive and the local the least progressive. Thus, if the burden of cleaning up the waterways is borne largely by the Central Government (directly or through assistance from international agencies) then the poor will not be paying a relatively high price for a service which is not a major priority for them. However, we need more careful studies of tax incidence to draw such inferences.

Cleaning up the waterways produces "spill-over" costs and benefits to the larger metropolitan area, and not just Madras City. Low flow augmentation may affect agricultural interests outside the City. Navigability of the Buckingham Canal may produce benefits for a wider area. The Cooum, the Buckingham Canal and the Adyar flow through the Madras Metropolitan Area and beyond. It is essential, therefore that a metropolitan approach be used in financing and management.

The Social Impact of Pollution Control

In discussing the costs and benefits of pollution control, we have assumed that there are societal benefits by forcing pollute to "internalize" the costs of their

activities. In cases where the polluters are the public or public agencies, we have suggested that the Government must bear the cost of pollution control. However, we must note that most forms of government intervention affect different groups differentially. Thus, the pollution control programme must take cognizance of these differential impacts, from the standpoint of equity. Measures to mitigate adverse impact, or redesign of the entire programme may be needed, in extreme cases. We will discuss three of these impact areas briefly.

a) <u>Impact on the Poor</u>.

Amenity resources such as clean air and clean water are demanded as public goods by those whose leisure and education enable them to appreciate such considerations, (Arrow, 1970). While the poor may be aware of the damage that pollution causes to their health and well-being, they may not consider these amenities as high priorities when compared to employment, housing, and other basic needs.

In the case of the waterways, part of the process of cleaning up may well involve the relocation of the poor who live on the banks. The major reason for relocating the poor is to reduce the sullage and human wastes that they contribute to the waterways. The <u>cost</u> of relocation can therefore be considered to be a pollution control cost, in that a source of pollution is moved elsewhere. It would be necessary to expend resources to ensure that proper sanitation and drainage facilities are available at the new location. Otherwise, the same wastes will contaminate surface and/or ground water elsewhere. We must also ensure that we are not imposing other private costs on the poor by relocating them, such as increased cost of transportation and other inconveniences.

We must estimate the various benefits from relocation. A decreased level of wastes will improve the quality of the water, and, will produce benefits in terms of health, ecosystem, etc., which we have discussed, for the City as a whole. But, we must also remember that a large share of the benefits accrue to the poor both directly and indirectly. They are no longer exposed to a) the health hazards of a severely polluted river (polluted by many sources other than themselves) and b) the flood hazards during the monsoon season in terms of damage to health, property, etc. They also benefit in terms of better housing, better sanitation, etc. The City benefits in terms of lower costs in dealing with damage to health and property of the poor (i.e. these costs are averted). In terms of equity, it is important that the poor be "compensated" for leaving their current homes. The compensation could essentially be the provision of a new dwelling elsewhere (i.e. relocation). It would be undesirable to " **evict** " the poor without providing an alternative dwelling. The major question is whether this alternative is acceptable, to the poor in terms of location, services, etc.

The cost of providing land for housing in any metropolitan area is high. In fact, the poor choose to live on the banks of the rivers or canals precisely because rents are either low or non-existent. Consequently, we may have to incur very high costs of relotion which may not be justified in terms of the benefits but would be desirable in terms of equity. In other words, we can describe the expenditure for relocation to be a "specific redistributive measure" which forms part of the policy package of cleaning up the waterways. The principle that we would like to use in a situation like this is the Rawlsian one namely,

"Policies should be designed to maximize the well-being of those with minimum wellbeing". i.e..the least advantaged should not be made worse off (Rawls, 1971).

b) Impact on Land-Owners

Another distributional issue relates to the land-owners along the waterways who will benefit due to a rise in land values, when the waterways are cleaned up. Given the existing system of property rights, there is not a great deal that can be done to capture the "unearned surplus" of private parties. However, in the case of vacant public land, the Government could either lease the land on a commercial basis, or develop it for parks or recreational purposes, which will provide benefits on a a wider scale, and help generate revenues that can be used to defray some of the costs of the programme.

c) Impact on Future Generations

Finally, a major rationale for environmental management is the benefit to future generations, who remain unrepresented in current political and economic decision making. Many environmental resources are abused or plundered for short-term benefit, giving little thought to the impact of such actions on future generations. Economists have called this kind of impact - intertemporal equity. There is substantial justification for improving water quality, if we take into consideration the well-being of future generations. This particular argument is bolstered if some of the impacts of pollution are irreversible. Traditional economic analysis provides few safeguards for future well-being, because the discounting procedures normally used tend to give low weights for future consumption, (Heal, 1974). Heal, therefore, argues that we should determine the optimal

depletion rate which would maximize the benefits that will accrue to the generation receiving the smallest benefits. The solution to this choice problem of intertemporal allocation of resources turns out to be one of selecting the highest possible steady, sustainable consumption path (Heal, op.cit.). It is interesting to note that the concern of the economist for intertemporal equity is congruent with that of the environmentalist who advocates sustainable development. Thus, proper management of natural resources, such as water essentially implies a sustainable level of consumption.

If we continue to use the waterways as sewers for effluent disposal, it becomes increasingly difficult and expensive to reverse the process. However, if we can restrict the discharge of effluents into the waterways, and allow for some regeneration of water purity, we can obtain service flows (in terms of uses) in future time periods (Mc Inerney, op.cit). The waterways can then become a renewable resource which can continue to yield benefits to future generations if it is managed properly.

Summary

In this chapter, we have tried to provide the rationale for public intervention in water quality management. We have argued that the "negative externality" aspect of pollution, and the "public good" aspect foreclose the possiblity of a private or market solution to the problem, particularly in an urban context.

We then suggested that the benefits and costs of pollution control be examined in order to determine the appropriate level and nature of public intervention. We pointed out that problems of valuation which are

inherent to many publicly provided goods make it very difficult, if not impossible to quantity the benefits. So, we discussed the major benefits of pollution control in a qualitative manner. On the cost side, it is necessary to first have a detailed appraisal of the technological options for pollution contro. Unfortunately, such an appraisal is currently not available, and is well beyond the scope of this research. However, we have provided some general guidelines in this chapter, and in later chapters regarding such an appraisal. We suggest that following such a study, a cost-effectiveness approach be used for future planning.

We then discussed the financial aspects of a pollution control programme for the waterways. We suggested that a <u>metropolitan</u> approach be used, since the beneficiaries of the programme live in the Madras Metropolitan Area. While non-local sources can be tapped for financing capital costs, the long-term repayment, operating costs, etc. must ultimately be paid by the beneficiaries.

Lastly, we pointed out that any large public programme will have distributional or social impacts. We discussed three kinds of social impacts-on the poor; on private and public land-owners; and, on future generations. Mitigation of adverse impact is needed if the programme is to succeed. Public participation in planning will bring the concerns and interests of these various groups into focus, and help planners and decision makers in re-designing the programme accordingly. We will discuss this issue in detail in Chapter VII. In the next chapter, we spell out a <u>methodology</u> for water quality management that can be used in planning for the waterways of Madras.

Chapter VI

PRINCIPLES OF WATER QUALITY PLANNING AND MANAGEMENT

In the preceding chapters we discussed the problem of pollution of the Cooum and other waterways, the ecological and health impact of pollution, and the rationale for pollution control. In this chapter, we will develop a set of principles that we can utilise in planning for the waterways. However, water quality planning and management is wider in scope when compared to a pollution control programme, in two basic ways.

First, a water quality plan for the waterways must include water quantity considerations, such as flow rates, flood control, wastewater reuse, etc. There are also interrelationships with land management, water supply and solid waste management. Thus the scope of planning is breader in a functional sense.

Second, we would like to "internalize" all the external effects, and bring them under the purview of a management agency that would have the powers to control and coordinate actions over a wide area (Scott, 1979). We have to use a regional approach in water quality planning. Thus, we have to include a spatial dimension to our earlier "dimensionless" analysis. We will incorporate these functional and spatial aspects in developing a set of planning principles. We will also address management aspects such as the legal, institutional and financial framework within which the planning should be undertaken.

Process of Water Quality Planning

The process of water quality planning is similar to other planning processes. It consists of a sequence of steps which are essentially iterative in character. These steps include:

A. Plan Formulation

1. Statement of Water Quality Goals
2. Interrelationships between Water Quality and other related factors.
3. Identification and Scope of Water Quality Problems.
4. Technological Alternatives.
5. Management Aspects.
6. Public Participation in Plan Formulation
7. Screening and Plan Selection

B. Plan Implementation

C. Plan Review and Evaluation

Since the scope of this research is limited to plan formulation. We will not concern ourselves with issues of implementation and review. We will note, however, that since the planning process is iterative, a monitoring system is needed for managing the process.

The process that we have outlined is typical of a "rational" planning process, in the sense that the planner examines all alternative strategies, before selecting a set of suitable strategies using various criteria. In practice, it is impossible to list all strategies and some sort of prior screening produdure has to be adopted to limit the number of feasible strategies. Such a process either implicitly or explicitly imposes some of the subjective judgements of the planner on the process. We will now go on to discuss the various steps to plan formulation.

1. Water Quality Goals

The first step in the planning process is to define the goals of water quality management. "What should be

the allowable level of pollution?" "How clean should the waterways be?" are questions that need to be addressed. There is an intuitive feeling that in the case of urban waterways, pristine water quality that can support a complex ecological system is not needed. (Afer all, the Cooum and the Adyar are not mountain streams.) On the otherhand, having an open sewer with gross pollution is obviously unacceptable. There a number of intermediate possibilities depending on the projected use of the river. It is necessary, therefore, to specify a realistic level of water quality that is adhievable.

There is a legal lower limit to water quality that is contained in the Indian Standards - Tolerance limits for inland surface waters subject to pollution (IS: 2296 - 1974). We can either use this standard or something higher as the basis for planning. Only then can we examine various alternatives to see if they could achieve the desired level of water quality in a cost-effective manner. Without such a framework of goals, it would be impossible to evaluate either the desirability in the sufficiency of the technological options for cleaning up the waterways.

We may also have other goals in cleaning up the waterways such as recreation, navigation, flood control, etc. It would be useful to specify these goals as clearly as possible, so that the planning can be done in a comprehensive manner. We may also have social goals which we might wish to incorporate as constraints. For example, we might not want to make the poor worse off.

The purpose of goal formulation is to ensure that we have a benchmark for comparison that we can use during and after implementation. If for instance, our water quality goal for the Cooum estuary is a minimum level of 2 mg/1 of dissolved oxygen, we can check periodically to

see if this goal has been achieved. We may find that a particular goal is too ambitious, and may wish to scale it down. However, we cannot monitor the process, if we have no goal at all.

As a corollary to goal formulation, is the development of a system for monitoring and evaluation. In the case of tha water quality goal, we must have a network of sites at the three waterways, wnere measurements (physical, chemical and biological) are made periodically. Only then can we assess the impact of any clean-up programme.

An additional analytical device is water quality modelling. Models of the Cooum and the Adyar have been attempted (Thanasekharan, 1978; Arumugam, 1979; Sundaresan, 1957). There are many problems and limitations of mathematical modelling, particularly in estuaries. We will not go into those problems here. A major limitation which is worth mentioning is that most water quality models focus attention only on oxygen demanding wastes, and, not on nutrients (which cause eutrophication) and on toxic materials. On the other hand a model allows us to obtain a good conceptual understanding of the water quality profiles in various stream segments.

Even if we do not undertake modelling, we must atleast have monitoring data. That is the only means of verifying (other than visual observation) if pollution has been controlled. It becomes particularly important when we wish to use the waterway for some productive use. If we want to restore boating on the Cooum, we must ensure that the water quality is suitable for that purpose. In a similar manner, we may wish to use various criteria to monitor achievement of other goals.

The monitoring process has to be carried out by an agency (or contracted out to a laboratory) that has the necessary competence and facilities. Since the consequences of errors (in analysis) may be significant, it is important that adequate quality control procedures be followed, and that the laboratory be certified by a higher standard setting authority. The monitoring agency must also have the competence to monitor other goals, particularly those that are related to water management.

2. Interrelationships with Water Quality

Water quality planning cannot be conducted in isolation. There are important interrelationships with water supply, land use planning, urban runoff, flood control and solid waste management (Whipple, 1977). We will review these briefly, since we have already made reference to those interrelationships at different places in this report.

(a) Water Supply - As mentioned earlier residents of the Madras Metropolitan Area rely on both surface and ground water sources. Surface runoff or waste discharges can enter aquifers and pollute ground water. Excessive mining of ground water in coastal aquifers can lead to contamination by sea water intrusion. A more critical point in a water starved area is the use of "potable" water for lower grade uses such as industrial cooling. Advanced treatment of wastewater could make it an alternative source for industry. Of course, water for low-flow augmentation is very unlikely if there is inadequate water for drinking purposes. Thus, a regional "plan" for water quality management must include these considerations.

b) Land use planning

The use of land for various purposes - housing, industry open space, commerce, etc. has a close relationship with water management. Wastes of various kinds are discharged, which if improperly managed pollute the water ways. Using up all available land for development causes problems of drainage (and ultimately of pollution), and also increases the amount of impervious surface thereby decreasing percolation. Building in the flood plains of the waterways causes flood hazards during the monsoon season. There is, therefore, a very close relationship between land and water management which must be considered in the plan. It is particularly vital in a context where urban growth is occuring rapidly both in terms of population as well as in land area.

c) Urban runoff

We have already discussed the pollution caused by stormwater runoff. We must also be concerned about the flooding caused when there is little chance for percolation. Another problem that we have not discussed very much is that of sedimentation. Storm runoff carries vast quantities of sand, construction debris and road surfaces into the drains and into the waterways. The sediment load in the Madras City waterways is extremely high, particularly in the case of the Adyar. Erosion control practices, sedimentation ponds, etc. can decrease the sediment load into the waterways. Apart from being a pollutant, sediments can also make it difficult to use the waterways (in the future) for navigation or recreation.

d) Flood Control

We have already addressed the problems of flood hazards from poor land management and from urban runoff. An interesting point is that if we can detain storm

runoff we can solve both a water quality problem, as well as flood problem simultaneously. In addition, if the water is not very polluted we might be able to use some of the water for drinking (after suitable treatment) or for other lower grade uses.

e) Solid waste management

Apart from the pollution problems from solid wastes that we discussed in Chapter III and elsewhere, we have some other interesting interrelationships. If we control pollution by proper treatment of sewage, urban runoff, etc. we still have the problem of disposing the sludge (i.e. the residual solids left after treatment). We may be able to burn it to generate biogas, or we can use it as fertilizer. Unfortunatley, sewage sludge in urban areas contains heavy metals and other contaminants which may affect grounwater or enter the flood chain if it is disposed on land. There are also problems in burning if it contains hydrogen sulphide. In any case, the issue of sludge disposal in an environmentally sound manner must be considered in planning.

3. Identification of Water Quality Problems

Since we have discussed this issue in detail in Chapter III, there is little need to repeat the familiar litany of water quality problems in Madras. However, two aspects related to the planning process need to be highlighted. First, the studies that we mentioned in Chapter III were conducted at different points in time by different investigators. It is necessary that at the time of plan formulation, the monitoring agency provide base-line data (i.e. at time t=0) for planning. Data must be gathered from various stream segments of the waterways periodically during the base year. The

monitoring programme should continue through plan implementation in order to determine the water quality impact of the clean up programme. It is also important to have seasonal data, particularly during the monsoon, to determine the contribution of storm drainage. Second, there must be a detailed inventory of pollution sources-the location, quantity discharged, and, characteristics of the waste. This requires a different kind of monitoring known as effluent monitoring (as contrasted to ambient or stream monitoring). Only then will we know whether the quantity and quality of effluents entering the waterway have reduced after the clean up programme has been initiated. Such an inventory will give us precise information on the nature of the wastes entering the waterway. A careful inventory of sources is a prerequisite for any water quality planning exercise. In this report, we have referred only to categories of wastes with very little quantification. We have also ignored the spatial aspect of location which is crucial for detailed planning.

4. Technological Alternatives

While in theory we ought to consider all feasible technical alternatives for water quality management, in practice it would be impossible to do so. We will, therefore, provide a brief summary of the different alternatives that are available without getting into the details of each alternative. We can categorize these alternatives in three broad categories:

a) Treatment of the Waterway
b) Treatment of Wastes (which are then discharged)
c) Source Reduction

We will discuss each of these alternatives briefly.

a) Treatment of the Waterway

This approach assumes that a certain quantity of wastes has already been discharged into the relevant waterway. It is then possible to treat the river (or canal) itself, and, control its pollution by a number of different ways:

i) Dilution with either fresh water or seawater:

Despite the general maxim that dilution is not the solution to pollution, it remains a favourite solution of engineers. It is true that dilution increase the assimilative capacity of the waterbody, and a certain amount of pollution control is achieved. However, non-degradable wastes are merely diluted, but not removed.

Dilution is possible by providing fresh water from the headwaters (unlikely under drought conditions) or by using industrial cooling water. It is also possible to pump seawater and use it for flushing.

ii) Removing the Sandbar:

In the specific cases of the Cooum and the Adyar, the removal of the sandbar at the mouths of the two rivers, will cause the sea to come in at high tide. During low tide, the wastes in the rivers will be flushed into the sea, which acts as a massive sink, i.e. the wastes are ultimately degraded by the sea.

iii) Aeration

To degrade organic wastes, it is possible to install mechanical aerators near the estuaries. The aerators will ensure that the river has the necessary dissolved oxygen to

degrade the wastes. This method has been used in West Germany and in the U.S.A. (Whipple, 1977). Another means of aeration is to use weirs, so that contact with air is increased. However, this method may not work very well in slow moving streams like the Cooum and Adyar, where the gradients for flow are very small.

iv) Biological Treatment:

This procedure simulates the process in a sewage treatment plant. By culturing certain species of filter feeding shelfish in the estuary, it might be possible to reduce the level of pollution (Azariah et al, 1984) However, it is necessary to ensure sufficient dissolved oxygen for the shelfish to live. Therefore, it would not be possible to implement this technique without re-course to (ii) or (iii)

We are providing only a sketchy description of these techniques, because the focus of this report is on the socio-economic aspects, and not on the technological aspects of water quality management.

b) Treatment of Wastes

We use the generic term "wastes" to refer to sewage, urban runoff, sullage, industrial effluents, etc. We will discuss the treatment of each separately.

i) Sewage:

Sewage has to be collected and transported to sewage treatment plants. After treatment, preferably at the secondary level, the effluent can then be used for irrigating grass, or for industrial cooling, or released into the waterway. The major point is that the level of treatment must be high enough to ensure that the final effluent does not pollute the waterway.

ii) Urban runoff:

Since a very large quantity of runoff occurs during a very short period (during the monsoon seasons) it would never be economically viable to treat storm-water like sewage. If we could use grit filters and store stormwater in sedimentation basins, atleast some of the solids and heavy metals would settle (i.e. similar to primary treatment). Moreover, it would reduce the possibility of flooding. The major problem is to find adequate low-lying land for sedimentation basins. This type of treatment has not been considered in the Madras context.

iii) Sullage

Sullage from slumdwellers and from neighbouring drains could either be routed to the sewage system or to leach pits (if soil conditions permit).

iv) Industrial effluents:

Industries have to ensure that their wastes are adequately treated or reprocessed before discharging into the waterways or on land. Currently, no major industry discharges into the Madras Sewer System which implies that they are discharging either on land or into water bodies. It is possible in certain cases to consider pre-treatment before discharging into the Municipal system.

c) Source Reduction

There are a number of different ways of reducing wastes entering the waterways, apart from treating the wastes. These include

(i) Process Changes

In the case of industries, it is possible to institute changes in the process which will reduce the

quantity of wastes generated.

(ii) Recirculation

By including some minimal treatment, it is possible to circulate the effluent and not release it to the environment. This can be done by industry and by large residential/commercial buildings. Some owners of large buildings in Bombay have been recirculating their domestic effluent after treatment for use as cooling water for air-conditioning, (Alagarsamy, 1988).

(iii) Wastewater Reuse

It is possible to treat wastewater sufficiently, so that it could be used by industries for cooling, or for watering parks, or for other lower grade uses.

(iv) Life Style Changes

These are the simplest technologically, but the most difficult from a social standpoint. These include changes in the ways of disposing garbage, of using public conveniences instead of the streets, of not using stormdrains for sewage or garbage, etc.

Thus, we could improve water quality of the waterways by combining a number of different alternatives, which are <u>not</u> mutually exclusive. However, the <u>optimal</u> combination of options requires some effort at cost-effectiveness analysis. We must try to use those alternatives whose costs are minimum, but provide the desired level of control.

5. Management Aspects

Water Quality Planning is not a purely technical exercise. It requires some consideration of the management aspects - in particular, the legal, institutional and financial dimensions. We will discuss each of these briefly.

(A) The Legal Framework

Water Pollution in the Indian context comes under the purview of three major Statutes:

i) Water (Prevention and Control of Pollution) Act, 1974.
ii) Water (Prevention and Control) Cess Act, 1977.
iii) Environment (Protection Act,) 1986.

The 1974 Act provided for the establishment of Pollution Control Boards at the State level. Since water is a State subject, the authority to regulate water pollution is vested with these agencies. There is also a Central Board which is responsible for standard setting, conducting water quality studies, etc. The Act provides a regulatory system for monitoring violations of standards, and, for taking legal action against polluters.

The Cess Act empowers the Government to collect cess from industries using any source of water. The cess is not an "effluent tax" in the sense that we discussed in Chapter /. It has become a source of revenue for the Pollution Control Boards.

The Environment Protection Act (1986) is an "umbrella" Act that was passed following the Bhopal Tragedy. It would not be possible to discuss all the provisions of the Act. A good summary of the salient features is given in Oomachaen (1987). The Act empowers the Government to make appropriate rules by fixing quality standards; provides powers of search and seizure; empowers the taking of samples and the establishment of laboratories; provides penalities for contravention, etc. The Act provides sweeping powers to close down a polluting industry. But more importantly, officers of the Company who violate provisions of the Act can be held criminally liable. Even heads of departments of Government agencies can be proceeded against and punished

if deemed to be guilty. Anew aspect of the 1986 Act is that empowers a private citizen to prosecute a polluter after giving sixty days notice to the Government or the designated environmental authority. Also, civil courts are barred from entertaining any suit or proceedings in respect of anything done under the Act. (Oomachen, op.cit.)

The power of the Pollution Control Boards to enforce the 1974 Act was restricted. Many offending industries obtained stay orders from the High Courts against prosecution. But, in a landmark ruling, the Supreme Court (in its directive of September 22, 1987) has urged the High Courts to dispose of cases relating to pollution on a priority basis. The High Courts were directed not to issue stay orders. Sepcifically, the Supreme Court has taken the following actions under the Environment (Protection) Act:

i) Has reversed the decisions of the Allahabad and Lucknow benches of the U.P. High Court, and, has ordered the closure of 29 tanneries until they set up treatment plants;

ii) Has issued directives binding on <u>municipal bodies</u> asking them to submit detailed affidavits regarding the works being done by them to make the Ganga free of pollution;

iii) Has directed that requests for no objection certificates by new industries be rejected until they make proper arrangements for treatment plants/(IAWPC Newsletter, 1988)

The effect of these rulings is that neither industries nor municipal bodies can <u>wilfully</u> continue polluting water bodies. There are now sufficient provisions to take legal action against them if they are not making efforts in good faith to control their pollution.

In the absence of legal action that agencies such as the Pollution Control Boards can take, private citi-zens or citizens groups can move the courts after giving sufficient notice. This provision adds a powerful dimension to public participation. There are clearly costs in terms of time and money to initiate suits. However, this is a major rationale for forming citizens groups to take polluters to court, and, make them pay for their offences. If the polluter is a government department, it is possible to sue not only the department, but its head, if the department shows no interest in dealing with the problem.

We have so far discussed national legislation. The responsibility for water pollution control at the regional (metropolitan) level in the present context rests with the Madras Metropolitan Water Supply and Sewerage Board (Metrowater).

The Madras Metropolitan Water Supply and sewerage Act, 1978 empowers the Board, " to prevent pollution of any water including any water source, water course or channel utilized for the purpose of the Madras Metropolitan Area" (Tamil Nadu Act 28 of 1978). However, by executive order, Metrowater is responsible for pollution control only within the Madras City boundary. Outside the area, but within the MMA, pollution control is the responsibility of the Pollution Control Board.

If any event, Metrowater as the operator of Sewage treatment facilities has the dual role of being both the polluter and the regulator, atleast within Madras City limits. The executive order was presumably drafted to relieve Metrowater of the responsibility of regulating large water using industries, who are located in the MMA but are outside the City limits. But, the fact remains that <u>pollution control of the waterways is a major statutory responsibility of Metrowater</u>.

The Madras Metropolitan Development Authority (as a regional planning authority) can "prepare regional plans and carry out or cause to be carried out such works as are contemplated in the regional plan". While in practice, the MMDA has not been engaged in water quality planning per se (atleast in the sense that we have been discussing), it has prepared a land use plan for the MMA, and, is engaged in a variety of activities associated with land management. There is little doubt, therefore, that MMDA has a major role to play in regional water quality planning, because of the interrelationships between land and water quality management that we have discussed earlier.

At the local level, the Madras Corporation has the following legal responsibilities under the Madras City Municipal Corporation Act, 1919. These responsibilities include:

a) Maintenance of a system of public drains (Sec.176)
b) Provision of ublic latrines (Sec.184)
c) Provision for removal of rubbish and filth (Sec.194)
d) Provision for daily cleaning of streets (Sec.198)
) Provision for cleansing of polluted wells or stagnant water (Sec.266)

Thus, the Madras Corporation can legally take actions in a number of different ways to manage wastes, that might otherwise enter the waterways and add to the water pollution problem. Therefore, in any water quality plan the Corporation has an important role to play, atleast within City limits. Panchayats may have to do something similar in the suburban areas.

(B) Institutional Aspects

In describing the legal provisions for pollution control, we have also addressed the institutional issues, in particular the roles of the Pollution Control Board, MMDA, Metrowater and the Municipal Corporation. We must also consider the potential roles of various State agencies.

i) The Public Work Department:

The Irrigation Wing of the PWD is the most important agency dealing with issues of water management in the State. All major works with regard to rivers, streams, lakes, canals, etc. are the responsibility of the PWD. The earlier Cooum project was also uhder-taken by the PWD. Most of the expertise resident in the PWD has to do with management of water quantity, not quality. They routinely deal with such areas as flood control, irrigation dams, reservoirs, navigation, etc. all over the State.

The water supply and drainage functions of the PWD, have now been transferred to the Tamil Nadu Water Supply and Drainage Board (TWAD). However, TWAD does not have any responsibilities in Madras City because the same functions are essentially carried out by Metrowater except in some of the suburban parts of the MMA. (For example, in the provision of Palar Water to Tambaram and neighbouring areas).

The major point, however, is that the drafting of a regional water quality plan, the PWD has a role in that there are interrelationships between water quantity and water quality management. However, this role should not be expanded to subsuming water quality as one small part of a regional waterways plan, since the central problem of the waterways is water quality management not water quantity management.

ii) Housing agencies

There are two agencies in the State involved with public housing, namely, the Tamil Nadu Housing Board (TNHB) and the Tamil Nadu Slum Clearance Board (TNSCB) These agencies come into the picture, because of the potential relocation of 30,000 households who live on the banks of the waterways. We have discussed the pros and cons of relocation in Chapter 17, and will

not repeat them here. Both the Boards have housing projects in the MMA for the urban poor, such as "sites and services", slum improvement, tenements, etc. Relocation if it occurs, will involve moving these people to these housing projects, or to a new project managed by them.

Thus, the institutional aspects of water quality planning soon become very complex. As we have pointed out, all these agencies have some role to play in planning and in implementation. But the key point is that management of the project cannot be done by an interagency Committee. There must either be a "lead" agency or a new agency for managing the project. We have also repeatedly stressed the need for that agency to have the technical competence in water quality management. The managing agency must be able to monitor the process both technically and administratively. It does not make sense for a non-technical department of State Government to carry out this function. Furthermore, as a regional project, the managment must be done by a regional agency, not a State agency or a Central Government agency. Only a regional agency can balance regional priorities, and remain accountable to the local population throughout the planning process.

An inter-agency committee on the other hand could serve in an executive role. Similarly, a citizen's advisory committee could be set up to assist and monitor the management agency, and also serve as a forum for public participation.

(C) Financial Aspects

The general financial principle that is used in water quality management is the "Polluter Pays Policy" (PPP). In the developing country context, this principle has to be modified to include the ability to pay. The government and/or higher income groups may have to

subsidize the poor. if they happen to be the polluter(s).

In the specific situation of the waterways those sources of pollution who have the ability to pay, must pay the full costs of treatment or source reduction. For example, industries discharging wastes (above the effluent standard) must be required to pay the full costs of treatment. In the case of small business whose economic viability is seriously affected (i.e. they are genuinely unable to pay the full cost), the government may wish to subsidize the cost of treatment on a case-by-case basis. Middle and upper income households, restaurants, and other commercial units who have connected their sewers to stormwater drains, should be required to pay the full cost of sewer connection. Industries that buy treated wastewater and use it for cooling, should pay the "shadow price" (ie. the opportunity cost of groundwater, which they are replacing with wastewater), and so on. The entire issue of pricing of water and wastewater must be examined carefully.

However, we are still left with major public sources of pollution such as from stormwater drains, sullage etc. Even in the case of sewerage, we must be concerned about the costs of collection and treatment which are massive. In other words, we may have large capital costs (lumpy investments) that have to be financed. While we may be able to finance operating and maintenance costs through user fees (the PPP approach), we cannot do the same for capital costs.

In some countries, the national government provides a major share of the costs of building treatment plants. There is no such provision in our environmental legislation. However, the Central Government through plan funds has allocated funds for water supply and sewerage.

The availability of funds during the Sixth Plan for Tamil Nadu was Rs.124 crores for urban water supply and Rs.31 crores for urban sanitation (Deivamani 1985). Metrowater has utilized these funds, as well as funds from the World Bank for their capital improvement programme. The major problem with projects of this kind in India and abroad are two-fold.

(i) The easy availability of credit for capital facilities results in unnecessarily expensive facilities being constructed;

(ii) There is often inadequate funds for operation and maintenance, because cost recovery is not properly planned. Unlike traditional water supply or sewerage systems, the clean-up and maintenance of water quality of a river (stream) may not generate internal funds consistently. It may be necessary to resort to some sort of taxation or rely on general revenues of the State Government. This, in turn, raises some questions of equity that we discussed in Chapter

In summary, we must have clear estimates about the <u>sources</u> and <u>uses</u> of funds. In terms of uses - the extent of capital costs and the spreading of investment over the lifetime of the project, ongoing costs of operation and maintenance; interest charges, and other administrative costs, etc. In terms of sources - the extent of reliance on State and Central Governments; levy of additional local taxes and user fees to pay for continuing costs; the means of repaying principal and interest charges, etc. We also need to concern ourselves with subsidies (for invididuals or businesses) who are unable to pay the levied amount or the cost of treatment, and how these subsidies will be financed.

6. Public Participation

We will not discuss the specific avenues of participation, since we have devoted the next chapter (Chapter VII) to this subject. We will reiterate a few principles mentioned by Sadler and Cox that the management of water resources is the application of knowledge to improve the contributions of water to socio-economic development. Their arguments can be summarized as follows:

1. The quality of management is directly dependent on the state of knowledge and its diffusion among these involved in the management process. The use of open planning processess and public participation provide important mechanisms for developing and transferring knowledge, particularly information concerning social values and public expectations.

2. The existence of adequate knowledge withim water management agencies must be supported by general awareness of water management problems and issues by planners, bureaucrats, and the citizenry. General public awareness is necessary because political feasibility of management activities is related to widespread public attitudes and perceptions. Political decisions not consistent with such attitutdes and perceptions are possib in individual cases, but continuing political support depends on general approval within the population. (Sadler and Cox, 1986).

Our small survey (despite its many statistical limitations) which we will discuss in Chapter VII indicates a high level of awareness of the problem. Since the process of planning has been comparatively closed, there has been less awarness of the details of the clean up plan. There is little doubt that a large majority will support any effort to clean up the waterways, if the effort is sincere and comprehensive, and not a repetitionsof earlier halfhearted attempts.

7. Screening and Plan Selection

The screening involves detailed consideration of the technical and management alternatives. As mentioned earlier, many of these alternatives are not mutually exclusive. In formulating the plan, we are not selecting one alternative; rather we are looking for a combination of system elements. The criteria that we would like to use include:

(a) environmental (water quality, water quantity, land use, etc.)
(b) economic benefits and costs
(c) legal (national, state and local laws)
(d) institutional (viability of existing institutions, need for new ones)
(e) financial (sources and uses of funds)
(f) Socio- political (awareness and support by the public, citizen groups, political parties, etc).

Clearly, not all the criteria are applicable to all the alternatives. For the technical alternatives, we might be more concerned with (a) and (b). For the management alternatives we might use (c) through (f). The challenge of planning is to mesh these alternatives in one coherent strategy which simultaneously meets water quality and other goals; is cost effective and does not make the poor worse off; is consistent with national, state and local laws; can be managed by existing/new institutions; can be financed suitably; and is acceptable to various groups in the metropolitan area. That may seem like a tall order; but the success of planning demands paying attention to detail. Many earlier programmes have fallen by the wayside because a rigorous approach was not used.

Water quality planning is a complex process with many actors - politicans, administrators, technocrats, academicians, consultants, public interest groups, and

the public. The difficulty is in designing forums whereby the interests of these groups can be rationally considered and included. There will be areas of conflict that may need discussion and resolution. However, the solution to these problems is not the "escapist" one of closing all discussion to non-governmental units. While the democratic process is slow and cumbersome, in the long run it will ensure the convergence of a wide variety of views. For example, it makes no sense to talk of relocation without some discussion with the people who live on the banks of the waterways (i.e. the affected group).

In principle, the process of water quality planning should be conducted at the following levels:

1) Technical planning - by engineers/planners in a lead agency working their counterparts in various government agencies, and with experts in technical institutions, industry, and consulting firms (local or foreign). There must be a clear delineation of all the major alternatives in terms of technological feasibility and economic viability. Sufficient cost data must be provided to determine cost-effectiveness.

2) Management planning - by administrators, planners, management consultants, socio-economic research institutions, etc., This process has to occur in parallel with technical planning.

3) Policy planning - by a committee of high level administrators, technocrats, and representatives of industry, academic and citizen groups. This group should provide overall guidance to the planning described in (1) and (2).

Major responsiblity for (1) and (2) must be taken by the lead agency, and, final reports must be prepared and submitted by that agency. Input could come from the other interested groups. Thus, the policy planning committee essentially guides the lead agency, and holds it accountable for planning. A similar set

up can be envisioned for implementation. It would be most unwise to fragment planning and implementation authority to a number of different agencies. While other agencies may have roles to play, there must be done in concert, and under the direction of a lead agency.

It may also be useful to have a citizens advisory committee who can provide input to the policy planning committee and the lead agency. Their role becomes critical during implementation. We have explained why this diffusion of knowledge is important. To government agencies in this country who have always operated within a closed system, this sort of "open planning" might be perceived as a threat. However, if the government is serious about implementing a successful project to clean up the waterways, it must include the citizenry in the planning process. There are significant benefits in the long run.

The planning process that we have suggested is an iterative one, which ultimately leads the way to formulating and selecting a specific plan of action. But, the "plan" is not a static concept - it is merely a guide for action. As implementation proceeds, it may be necessary to make modifications and revisions i.e. there must be reflection in action. This is the major reason for establishing a monitoring system internally, and, a citizens advisory committee externally. The feedback provided by these systems will help the lead agency and policy makers to make appropriate changes during implementation. Evaluation and review has to occur constantly, so that problems and difficulties are identified at an early stage before they become unmanageable. Close monitoring and scrutiny will ensure that resources are not squandered, and plan objectives are achieved to the maximum extent feasible.

We must point out in this concluding paragraph, that the principles of water quality planning which we have outlined, refer to an "ideal" planning process. But, on the other hand, it is not impracticable. We have tried to tailor the discussion to the problem "on the ground". In the last chapter, we will move from a normative discussion, to what has actually occured in Madras, and, the additional steps that should be taken to deal with the problem of the waterways. Before doing so, we will address the issue of public perception and participation which is central to any democratic planning effort.

Chapter VII

PUBLIC PERCEPTION AND PARTICIPATION IN POLLUTION CONTROL

The success of any strategy to clean up the waterways will depend on the interest and support given by the public. While the tasks of cleaning up will be executed by government agencies through their staff, consultants and contractors, the role of the public - citizens, voluntary groups, and the media - is that of a "watchdog", i.e. to hold the government accountable, and, to monitor the process of cleaning up. The public has to be sufficiently aware of the problem and the possible solutions, in order to assure effective implementation.

In this chapter, we will first take up the issue of public perception. We will discuss the results of a small survey conducted at the Trade Fair (in 1987) using various attitudinal and awareness measures. Despite its many limitations, the survey indicates a fairly high level of awareness of pollution of the waterways, the source of pollution, and, the need for control. In the second part of the chapter, we will discuss public participation. In particular, we will review the "Citizens for Clean Waterways" Campaign launched by the Indian National Trust for Art and Cultural Heritage (INTACH). The Campaign was instrumental in sensitizing the Government to the issue, ultimately resulting in the setting up of an inter-agency taskforce. Details of the report submitted by the taskforce will be discussed in the next chapter. In this chapter, we will focus attention on the process of public participation.

Public Perception

INTACH was provided with a pavillion at the Trade Fair by the Tamil Nadu Department of Tourism for the

purpose of improving environmental awareness among the public. The pavillion is located on the bank of one of the branches of the Cooum River. It is physically impossible for any visitor to the Trade Fair (and the pavillion) to miss seeing the river, and noting the high level of pollution. It was, therefore, an ideal location to conduct a survey on problems of water pollution, water use, etc. Since people of different socio-economic groups visit the Trade Fair, it was felt that the opportunity should be used to obtain their views. A small survey of about 100 people was done over a one month period using a questionnaire (in Tamil). The questionnaire was divided into four parts. The first part elicited information on demographic factors such as the age, sex, education, etc. of the respondent. The second part was on the pollution of the three major waterways - the degree of pollution, the sources of pollution, and the responsibility for pollution control. The third part related to the respondents' experiences with water quality problems, particularly relating to health. Questions posed included purification of drinking water, problem of wastewater disposal, mosquito problems and water related diseases. The last section related to the respondents' satisfaction with various urban environmental services, and his/her perception of the need to maintain a clean urban environment.

Background of Respondents

The characteristics of the respondents were 81% male 19% female; 59% below 30 and 41% above 30; 6.4% with primary school education, 47.9% high school education and the rest with college education. The use of a written questionnaire tended to bias the survey in terms of a more literate sample. In terms of employment, 42.9% said they worked for the government, 30.6% said they worked in the private sector and the remaining

were unemployed or not employed (in the case of college and school students). The highest frequencies were 4.5 and 6 member households which constituted 32.1%, 16.0%, and 19.8% respectively of the respondents.

To gauge the socioeconomic background of the respondents indirectly, they were asked two questiohs regarding their housing. The first relating to ownership, and, the second to rooftype. 53.% said that they lived in rental housing and 44.4% said that they owned their house. 27.0% lived in thatched houses, 23.8% in tiled houses, and 49.2% in houses with concrete roofs. While the survey indicates a high level of respondents who live in good housing, and a good number with higher education, there is also some representation of people from lower socio-economic groups. Thus, the survey cannot provide a weighted representation of the views of different socio-economic groups in proportion to their population in Madras City. Yet it provides some sort of aggregate picture of the views of a fairly wide spectrum of Madras City residents. (Visitors from outside Madras City were asked not to respond to t he questionnaire).

Perception of Pollution of the Waterways

Respondents were asked whether they had seen the Cooum, the Buckingham Canal and the Adyar. They were asked to comment on a three point scale for each waterway - very dirty, somewhat dirty and clean. They were also asked if the water could be used for any purpose such as drinking, bathing, washing clothes, washing alimals, etc. Next they were asked to identify the sources of pollution from among the following - industrial wastes, domestic sewage, stormwater, garbage, abuse of the banks. They were also asked if it was possible to control pollution and, if so who should do it.

Two thirds of the respondents categorized the Cooum and the Buckingham Canal as very dirty (polluted) and most of the others as somewhat dirty. The situation was reversed in the case of the Adyar where about two-thirds charatterized it as somewhat dirty and 12 per cent actually considered it to be clean. The perception of the averagge citizen is not significantly different from that of experts.

In terms of use, while two thirds of the respondents said that the water of the Cooum and the Adyar could not be put to any useful purpose, 85 per cent said that the Buckingham Canal could not be used at all. This picture is fairly consistent with the current level of usage of the waterways. The Buckingham Canal has currently little or no flow. We must point out at this stage, that many people have difficulty in identifying these three waterways <u>separately</u>, except possibly the Adyar. The survey did not try to test the respondents' geographical knowledge very closely.

The more important awareness questions relate to sources of pollution and their control. Since respondents could provide multiple answers, the percentage do not add to 100. 53.4 per cent mentioned industrial wastes, 61.4 per cent domestic seweage, 17.1 per cent stormwater, 30.7 per cent garbage and 38.6 percent abuse of the banks, as sources of pollution. While the media and the government agencies often mention abuse of the banks by slum dwellers, it is interesting that less than a third considered it a source of pollution. It is interesting that more than half mention industrial wastes and about a third mention garbage, which are comparatively lesser known sources of pollution. The <u>lack</u> of perception that stormwater can be highly polluting, (which exists in the minds of the public and even among technical people), is evident in the survey also; only 17% identified it as a pollution

sources. This is the only area where further water quality studies could be undertaken.

But, what is interesting overall is that 89 per cent of the respondents could identify atleast one source of pollution, and, most of them identified more than one source i.e. there is a high level of awareness of the sources of pollution. There was also a high degree of optimism about pollution control - 84.3 per cent said that the pollution of the waterways could be controlled, 12.4 per cent said it could not, while 3.3 per cent gave other answers.

In terms of the responsibility for controlling pollution 69.8 per cent of respondents identified it as a responsibility of government, 36.5 per cent as that of individuals, 59.4 per cent as that of industry, 11.5 per cent as that of other agents. (The percentages do not add to 100 because multiple answers were allowed). However, 97 per cent of the respondents answered this question (identifying atleast one agent), indicating once again a very high level of awareness of the need for pollution control. If we combine the responses to the latter two questions, we come to the conclusion that almost everyone is aware of the need for pollution control, but a few (about 12%) are sceptical that it can really be done. Fortunately, 84 per cent are still optimistic.

The general conclusion resulting from this set of questions is that the awareness in terms of the level of pollution, the sources of pollution, and the need for pollution control is very high. Whether this high level of awareness is due to the exposure given by the mass media (newspapers, radio, TV, and films) or due to environmental education or due to other reasons could not be determined in this survey.

Perception of the Pollution = Health Linkage

In Chapter IV, we discussed the pollution health linkage from an academic perspective. In the survey, we attempted to find out the perception by the public of this important dimension of pollution.

The first three questions in this part related to the source of drinking water. 37.9 per cent said they have access to corporation taps, 24.2 per cent to hand-pumps, 29.5 per cent to wells, and the remaining 8.5 per cent to other sources or combinations of the above. If we assume that taps and handpumps provide protected water, then about two-thirds have access to such water. The remaining third who rely on ground water (wells) are using a watersource that may or may not be reliable in terms of water quality. Incidentally, the number of people relying on groundwater in the Madras Metropolitan Area is roughly a million (about 25% of the population). Thus, our survey is reasonably consistent in terms of these proportions.

A third of the respondents (33.7%) said they drank boiled water; 22.10% drank filtered water; 5% drank boiled and filtered water; and 35.8% did not do any purification. While in theory, protected water does not need any purification, it has been shown that due to various flaws in the distribution system it would be better to boil the water. Filtering merely decreases sediments, but does not kill disease causing bacteria. Well water of course should be purified before drinking. About 15% said that they had their drinking water tested in a laboratory. This proportion sounds a little high, but there is no means of checking it for accuracy. Given the high level of water related diseases in Madras, more than half the respondents (55.8%) are taking a risk in consuming unboiled water.

The next three questions related to problems caused by stagnation and mosquitoes. Almost two thirds (63.5%) said that they had stagnant water near their houses, which is an indication that a better drainage system is needed in Madras. 78.9% complained of the ubiquitous mosquito problem. 89% were aware that mosquitoes are disease carriers, and many mentioned malaria and filariasis as diseases spread by mosquitoes. Given the high prevalence rates of both these diseases in Madras City, there is an urgent need to improve the drainage, as well continue the eradication programmes as vigorously as possible.

Regarding livestock, 82.1% said that they had livestock close to their houses, but only half (50%) considered them to be a problem. There is a need to increase the general level of awareness of the problems posed by livestock- the choking of sewers, solid waste (dung) disposal, transportation hazards, pollution of water courses, etc.

The last three questions related to the central question of water pollution and disease. When asked if contaminated water could cause disease, 93.7% replied positively. This is in sharp contrast to certain rural studies which show a low level of awareness of this issue. One respondent felt so insulted by the question that he wrote a sharply worded response on the questionnaire!

When asked if any family members had contracted water related diseases, responses were provided by 67 respondents, i.e. about two thirds of the sample. Of those who responded 53.7% mentioned jaundice (hepatitis), 38.8% malaria, 16.4% skin diseases, 10.5% filarisis, 6.0% cholera, 6.0% encephalits, 11.9% dysentry, 40.3% conjunctivitis, and 17.9% gastro-enteritis. (The percentages do not add to hundred

because multiple answers were allowed). This data is not comparable with the morbidity data in Chapter IV for two reasons. First, it refers to the household, not the respondent. Second, the time period is any time in the past, not just the past year. Furthermore, survey data cannot be considered to be very reliable because the sample size is small, and the respondents might take inaccurate, statements about the different kinds of diseases. For example, the 6.0% of figure for encephalitis is probably not borne out. There is also some possibility for error in translating the name of the disease to a popular (unscientific) rendering in Tamil. However, despite all these limitations, there seems to be little doubt that the prevalence of water-related diseases in Madras is high. The rates given in Chapter IV are likely to be conservative estimates based on actual reported cases. There are probably a very large number of unreported cases, particularly in the case of hepatitis.

The respondents were also asked if any members of their households had died from these water related diseases. Of the 88 who responded, 10 (11.4%) replied yes, and 78 (88.6%) replied in the negative. The high mortality rate from water related diseases underscores the fact that the social cost of diseases caused by pollution and insanitary conditions is not insignificant.

Perception of Urban Services

The last part of the survey deals with urban environmental services. The respondents were asked to express their satisfaction or dissatisfaction with the following services - water, sewerage, garbage, streets, hospitals, and parks. They were also asked to express their opinion about the Corporation's tree planting programme. Finally, they were asked if the responsibility for maintaining a clean city was that of the government or of individuals or both.

TABLE 8

Satisfaction with municipal services

Service	Yes	No
Water	51.7%	48.3%
Sewerage	42.7	57.3
Garbage Collection	45.6	54.4
Streets/Drains	46.5	53.5
Hospitals	51.1	48.9
Parks	48.3	51.7

As shown in Table 8, roughly half were satisfied and half were dissatisfied with the various urban environmental services. 21.3% held the government responsible for maintenance of environmental quality, 38.3% felt it was the people's responsibility, and 40.4% felt it was a joint responsibility. In a society which increasingly looks to government to solve every social ill, it is gratifying that a large majority (78.7%) perceived the role of the individual in maintaining a clean urban environment. Some of the respondents used the opportunity to write some additional comments expressing their dissatisfaction with the current state of the urban environment in Madras.

So fa we have analyzed the survey data on a question-by-question basis using simple frequency distributions. It is also possible to draw some overall conclusions by looking at the data collectively. There are a number of data reduction techniques for survey data such as factor analysis, cluster analysis, etc., but one which does not require strong assumptions like normality of the distribution, is a technique known as multidimensional sealing (MDS).

MDS is particularly useful when one has uncertain, fuzzy, or biased data. This method was especially developed to tackle problems of ordinal data input. The essential idea of this method is to tranform ordinal data into metric (cardinal) data, such that a new cardinal configuration bears a maximum resemblance (a maximum goodness-of-fit) with respect to the ordinal data. MDS uses ordinal rankings of similarities among objects (or items, attributes, etc.) It provides a geometric representation of the objects in an Euclidean space of given dimensionality by employing a certain geometric sealing algorithm. (Nijkamp, 1980). One version of MDS developed at the University of Michigan is called "Smallest Space Analysis".

This technique is particularly useful for attitudinal surveys, where we generally have ordinal data, and the assumptions of normality of distributions, etc., do not hold. Of the 41 items in the survey, 17 attitudinal items were selected for input. A two-dimensional space was specified, to make the interpretation easier. The items which cluster, together are closely related to each other, and, could be studied as a group. In igure 3, we observe the following:

(1) The six urban services satisfaction items form a cluster (These are evaluative variables, in the sense that the respondent is using an abstract standard for comparison).

(2) The perception items relating to the quality of each of the three waterways form a separate cluster. (These require awareness with some degree of evaluation).

(3) The perception items relating to the sources of water-related diseases (contaminated water, mosquitoes, but not livestock) form a cluster. (These are awareness

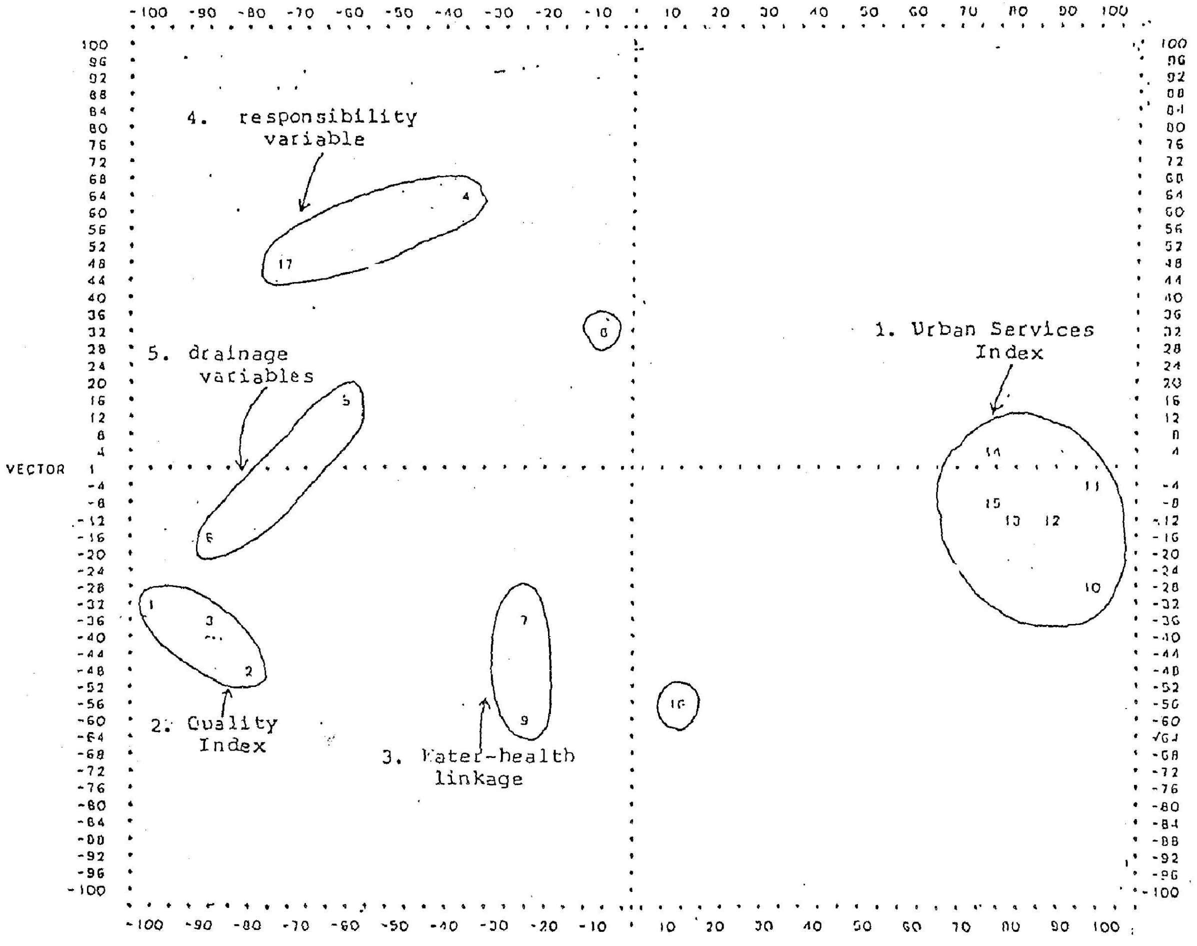
PLOT IDENTIFICATION TABLE FOR FIGURE 3

PLOT LABEL	VARIABLE	NAME
1	V10	COOUM QUALITY
2	V13	BC QUALITY
3	V17	ADYAR QUALITY
4	V20	POLLUTION CONTROL
5	V26	STAGNANT WATER
6	V27	MOSQUITO PROPLEM
7	V28	MOSQUITO DISEASES
8	V30	LIVESTOCK PROB
9	V31	CONTAM WATER PROB
10	V34	WATER SERVICE
11	V35	SEWAGE SERVICE
12	V36	GARBAGE SERVICE
13	V37	STREETS SERVICE
14	V38	HOSPITAL SERVICE
15	V39	PARKS SERVICE
16	V40	TREE PROGRAMME
17	V41	ENV.RESPONSIBILITY

FIGURE 3

MAY 29, 1987 SMALLEST SPACE ANALYSIS OF SURVEY DATA MINISSA

VECTOR 2 PLOTTED AGAINST VECTOR 1 VECTOR 2



variables, which assume a certain level of knowledge).

(4) The two items relating to individual/social responsibility, (namely, for pollution control and for a clean urban environment) form another small cluster. (These are also awareness variables, which require some minimum civic sense).

(5) The items relating to the drainage problem (namely stagnant water, and, suffering from mosquitoes) form another small cluster. (These are largely experiential in character).

The survey combines a variety of questions which ask the respondent about different aspects of the urban environment ranking from individual problems, attitudes, and knowledge. Thus it is better to cluster these before drawing generalized conclusions to problems of the city as a whole. The MDS is a convenient way of doing this with a geometric representation of the items in clusters.

Two of the seventeen items - one relating to the tree programme, and, the other relating to livestock do not form part of any of the clusters. While the tree variable is in the same quadrant as most of the urban services, it is still distinct from the others, and seems to be perceived differently. Similarly, the livestock problem is perceived differently when compared to contaminated water and mosquitoes as one of the sources of disease. We have commented on this earlier.

Thus, we have reduced the original 17 variables to 15 variables in five clusters. Since we have only two dimensions, we can think of the X-axis as the urban - services dimension, and the Y-axis as the pollution dimension. The urban services items seem to cluster around the positive X-axis.

The pollution variables seem to be largely in the second and third quadrants (negative X-axis). If we stretch the point a bit, we could claim that they fall in the negative quadrants, because of the failure of urban services!. In any event, items relating to levels of pollution, pollution-disease linkage, and the drainage problem, seem to fall in the third quadrant (with the exception of one item). Items relating to responsibility (for pollution control and for maintaining a clean environment) fall in the second quadrant. It must be pointed out that this geometric configuation of the various items, is generated completely by the computer. We specify nothing more than the number of dimensions. The logic of the responses (as represented by the numerical codes) automatically brings similar items together to form a cluster, indicating the power of this technique. Of course, there may be occasions where the resultant clustering violates our common sense notion of which items are closely related. In this particular data set, such contradictions were not evident, except in the case of the livestock item.

Three variables which are not ordinal in character, but which are important were not included in the analysis. These were: (1) sources of pollution (2) agents responsible for pollution control and (3) water purification methods. These are descriptive variables, but imply awareness. For further analysis, these were recoded as awareness variables, and, included in the analysis. Since a second MDS was not done, these variables were added to appropriate clusters.

The next step in the process was to form indices by combining the items in a particular cluster. Four such indices were formed (the drainage cluster was not included, since it is not a central issue). An overall awareness index combining three of the four indices was also developed. These indices were constructed as follows:

(1) Urban services satisfaction (by combining the six items relating to urban services)
(2) Awareness of pollution of the three waterways (by combining the three perception items relating to water quality)
(3) Awareness of pollution sources and control (by combining the pollution control perception item with the first two recoded items mentioned in the previous paragraph).
(4) Awareness of the pollution - health linkage (by combining the intellectual awareness of sources of water-related diseases, with the practical awareness of water purification to avoid such diseases).
(5) An overall awareness index (by combining indices (2), (3) and (4) with the last item, the responsibility for a clean environment).

We chose not to cluster the last item with (3) because we wished to restrict (3) to the issue of pollution, whereas in the overall index, we wanted to expand the scope to the urban environment as a whole. One could argue that we could have created these indices without resorting to a formal statistical technique such as MDS, but by using common sense. The advantages of using a a formal technique are as follows:

(a) It provides a geometric (or other analytical) configuration which aids the task of index creation; and,
(b) there is greater consistency in combing similar items otherwise, we might end up averaging widely divergent items (we cannot avoid averaging among respondents, but would like to avoid it among items). The computed index values are as follows:

TABLE 9

Awareness Indices

	Pollution of Water-Ways.	Sources and control of Pollution	Relationship with Disease	Urban Services satisfaction.	Over-all
High	76.8%	82.8%	44.4%	31.2%	83.8%
Medium	20.2	12.1	44.4	24.7	14.1
Low	3.0	5.1	11.2	44.2	2.0

(i) Urban Services Index: The frequency distribution of the index is shown in Table[9]. If we reduce the categories from six to three, the spread would be as follows - high 31.2%; medium 24.%; low 44.2%. We must recall, that respondents were merely asked if they were satisfied or dissatisfied with each of the six services. Therefore, a high value means that the same individual was satisfied with most or all of the six services. (i.e. high, medium, and low does not refer to a scale of satisfaction). We might recall that for each of the services, almost half expressed satisfaction. However, if we taken urban services as a whole, less than a third were satisfied. The more typical case was where individuals were satisfied with only a few services. In other words, even those who were satisfied with some of the services, expressed dissatisfaction with other services. Collectively, therefore, there is an urgent need to improve both the quality and the range of urban services. It is not enough to improve just water and sewerage services.

We also tried to determine if this satisfaction index was a function of sex, age, or satisfaction. Chi-square tests were run to determine if the satisfaction index was associated with any of these categorical variables. The results of this investigation indicated that at the 0.1 level of significance, age and sex were not associated with the index. However, level of education and the index were negatively associated i.e. higher the level of education, lower the level of satisfaction with urban services.

(2) Index of awareness of waterways pollution:

As shown in Table[9] 76.8% exhibit a high level of awareness, and 20.2% a medium level of awareness. The fact that the three waterways are polluted seems to be well known. From a policy perspective, there is very little need to educate the public regarding this issue. On the other hand, any schemes to clean up the waterways can capitalize on this high level of awareness in terms of public support for the programme.

(3) Index of awareness of sources of pollution and their control:

As shown in Table[9] 82.8% exhibit a high level of awareness in this regard as well. Once again, very little public education is needed, except in a few areas. There is much greater need to explain what the government intends to do, and, what is expected of the individual.

(4) Index of awareness of the water-health linkage: As shown in Table 44.4% exhibit a high level of awareness and 44.4% exhibit a medium level of awareness. The reason that this index is lower than the other two is because of the water purification variable. If we had excluded this variable, we would have had a figure of around 90% for high level of awareness. This

index is supposed to measure awareness of the sources of water-related diseases. But, although individuals may be intellectually aware, they often do not put their awareness into practice. In this particular case, although most people know that contaminated water can cause disease, only some take the precaution to further purify their drinking water.

(5) Index of overall awareness: Table[9] shows this index on a ten point scale. If we reduce this to three categories, we find that 83.8% exhibit a high level of awareness, 14.1% exhibit a medium level and, only 2% exhibit a low level. If our sample is at all representative of the population of Madras City, there is very little need to employ resources in "awareness creation". There is much greater need to build on this high level of awareness. As mentioned earlier, a sizeable majority recognize the problem. Education by private and public agencies has to focus on the specific duties that individuals should perform, such as not connecting their sewers to storm drains; not throwing their garbage on the streets and in the drains, not rearing livestock in their gardens; not relieving themselves on the streets or on the river banks, etc. The government should also inform the public on the steps it proposes to take. The veil of secrecy which seems to shroud programmes such as this one should be lifted, and a democratic process must be instituted to involve the public. We will take up a more detailed discussion of this topic in the next section.

The survey did not use valuation techniques in the sense that we did not query the respondents about willingness-to-pay or compensation demanded. It is quite possible that the large number of respondents who said that pollution of the waterways must be controlled, would not have been quite so enthusiastic, if they had been asked how much they would be willing to pay for control.

The incentive to act as a "free rider" is probably very strong. They would probably have had no difficulty in expressing support for an expensive clean up programme launched by the government! While most people want better urban services, not all are willing to pay higher property ta.es.

However, an encouraging point is that many of the respondents did indicate that the individual has a role to play in pollution control. If we take this statement at face value, the respondents expressed willingness to incur some of the costs of pollution control. Individual homeowners who currently have their sewers connected to storm drains, could pay the cost of a sewer connection. Instead of throwing garbage on the streets, some effort could be made for proper disposal. Some households pay a separate fee for removal by a bullock-cart. Use of pay toilets instead of using the streets, also represents a cost to the individual. The aggregation of all these individual costs could be substantial.

B. Public Participation:

In this section, we will discuss the role that the public can play in influencing public policy with regard to cleaning up the waterways. First, we will discuss the theory (or the political economy) of public participation. We will discuss the incentives as well as the disincentives affecting participation. We will particularly note the key role that voluntary organisations play as instruments for citizen participation. Next, we will review the major problems experienced by Indian voluntary organisations involved in environmental management. Lastly, we will discuss the efforts made by INTACH through the "Citizens for Clean Waterways" Campaign, and, provide a brief evaluation of the Campaign uptil the present time.

The Theory of Public Participation in Environmental Management:

In Chapter V, we noted two things about environmental resources such as clean water or clean air.

(i) The benefits of clean water accrue to the public in terms of reduced damages to health and welfare. i.e. they will experience an increase in their productivity (or welfare) if there is control of pollution. They have a stake in improving water quality.

(ii) Since clean water is a public good, any political action taken by one individual that successfully improves water quality,will make many others better off. Therefore, each recipient has an incentive to act as a "free rider". The result, as with any public good, is a less than efficient level of political action in favour of pollution control (Downing, 1984)

Although individuals know that they will be better off if water quality is improved they often feel that they do not have the clout to influence public policy. There is particularly true in the Indian context, where public attitudes which developed during the colonial period persist. Some of these feelings were reflected in the small survey, where quite a few expressed frustration at their inability to affect the actions of government.

An alternative to individual action is collective action through voluntary organisations. However, since voluntary organisations also produce public goods the incentive to act as a"freerider" remains. Each individual has to weigh the benefits and costs of joining a voluntary organisation. The costs include not only the membership fee (which is often nominal), but the time and effort he has to put into the activities of

the organisation. Unless, he is convinced that the benefits outweight the costs he will not join. Even though, he may be convinced about the objectives of the organisation, he might prefer to remain a "free rider". Some voluntary organisations offer other benefits such as magazines, books, nature trips, etc., to overcome the "free rider" problem (Downing, op.cit).

The cost of being effective in a political debate over environmental policy (or for that matter any public policy) is very high for an individual. By joining with others, the cost to any one individual is reduced. When the voluntary organisation has a large membership, the average costs are reduced, and the likelihood of effectiveness is increased. This in turn induces more individuals to join, decreasing average costs even further, thereby overcoming the "free rider" problem to some extent.

When the voluntary organisation is successful in improving environmental quality, it may end up losing members, because they do not see the benefit of continuing in the group. In some cases, the voluntary organisation may actually disappear. This happens with protest movements against particular projects such as dams, nuclear plants, etc. In other cases, the voluntary organisation may take more extreme positions as a result of its successes. In the most extreme situation, counter voluntary organizations may spring up in opposition. This has not happened in India as yet in environmental management,but may occur in the future.

The <u>success</u> of a voluntary organisation can be assessed in a number of ways. In programmes that deal with technically complex issues (as is the case in urban environmental protection), Krimsky makes the following recommendations:

1) Public participation must make a real difference - citizens should obtain access to the decision - making process at points where they can make a difference in the outcome.

2) Participation should broaden options, not narrow them-integrating more diverse interests into the decision-making process should widen the scope of possibilities by capitalising on the imagination of many different minds.

3) Those individuals, communities or regions which are asked to bear the greatest risk should have a "weighted input" into the decision-making process. Specifically, Rawls' Theory of Justice could be employed, i.e., in a society of unequal distribution, decisions should not make the least advantaged worse off.

4) When a technology (or project) selectively impacts a community, such that its residents bear special risks, then maximising local options for regulation should be consistent with the "weighted input" principle (Krimsky, 1984). In reviewing the "Clean Waterways" Campaign, we will use the growth model of voluntary organisations that we have discussed in some detail. We will then use some of Krimsky's principles to evaluate its performance with regard to the clean-up efforts in Madras.

Problems of Voluntary Organisations Involved In Environmental Management

Sethi categorizes environmental voluntary organisations in India in the following three groups:

1) Education and advocacy relating to the environment
2) Opposing public or private sector projects that are harmful to the environment or people dependent upon it.
3) Activities directly aimed at solving environmental problems (for example appropriate technology projects).

In some cases, groups may be involved in more than one type of activity (Sethi 1987).

However, regardless of the activity, there are a number of problems that voluntary groups face. First, is the lack of trained personnel to carry out in-depth technical and economic analysis, although they sometimes receive assistance from universities and other scientific institutions. Second, is the lack of access to authentic data from official sources on projects and programmes which have environmental implications. Third, is the lack of statutory support and judicial sympathy for efforts of voluntary groups willing to fight agents responsible for environmental pollution (Agarwal, 1985). In addition to these problems, is the ambivalent attitude of government. Some voluntary organisations are supported, funded and applauded for mobilising and organising people in projects that the government approves. At other times, the government might ignore the organisation by not providing data, and virtually refusing to acknowledge its existence. In extreme cases, the government may actually turn hostile, and try to restrict the activities of the organisation (Sethi, op.cit).

However, these problems and processes of conflict are central to the democratic system, where differences in perception always exist. These issues are also central to the ongoing debate over development priorities and strategies. While one may take a cynical position over the attitude of government with regard to environmental management, effective public policy will not materialize without continued prodding from voluntary organisations. This has been the case in almost every major country irrespective of political ideology. The level of effectiveness might vary from country-to-country and issue-to-issue, but the role of voluntary groups has been very similar. They have acted as "watchdogs" - monitoring the environment, raising protests when needed, and extending support when the government needed their help.

INTACH operates within these constraints and limitations, as do most Indian voluntary groups involved in environmental protection. However, INTACH has the advantage of operating in a major urban centre, i.e., Madras, in terms of access to resources and expertise of various public and private institutions. Although comparatively a new comer in the field, it successfully utilised many of these institutions to develop a broad-based programme of citizens participation known as the "Citizens for Clean Waterways" Campaign which we will discuss below.

First, a Seminar was conducted on June 14, 1986 on the theme, "River Cooum -- Let it be a Resource", in association with the University of Madras and the Madras Environmental Society. Papers were presented by environmentalists and scientists on various aspects of pollution of the Cooum River. The seminar concluded with a list of recommendations to the Tamil Nadu Government with regard to cleaning up the river.

Next, a public meeting was held on June 29, 1986, to launch a public campaign. The purpose was to seek public support for government action through a massive signature drive. The goal of the signature drive was to raise Rs.10 lakh through 10 lakh signatures of individuals, each contributing Rupee one. The campaign has a prominent industrialist as the Chairman and a former Chief Secretary of Tamil Nadu as the Treasurer.

Other public activities undertaken, as part of the "Citizens for Clean Waterways" campaign, were a boat rally and a mass rally. The boat rally was sponsored by the Madras Chamber of Commerce. Boats were taken out on the Cooum by all the environmental groups of the city. Clean water was symbolically poured into the Cooum. A mass rally attended by over 2,000 people marched on Madras City's major arterial road, Mount Road (Anna Salai) on November 22, 1986. The

rally was organised in cooperation with the National Service Scheme (NSS) of Madras University, and was attended by students of colleges and schools as well as by social service organisations. The boat rally and the march were well covered by major newspapers and television. These activities were designed as 'media events' to sensitise the general public to the problem.

INTACH has also taken the campaign to schools and colleges. Exhibitions of posters and photographs on the Cooum have been held at a number of schools and colleges in Madras City. A group of 10 students at the Madras School of Social Work took up the "Clean Waterways" campaign as their field work project. Workshops for NSS volunteers have been held, to train them environmental management. A slogan contest and a skit contest were organised with the "Cooum River" as the theme.

Apart from these environmental awareness and educational efforts, the campaign received a major stimulus, when four INTACH members were nominated to a government task-force, chaired by the Chief Secretary, Government of Tamil Nadu.

A working group of the task-force under the chairmanship of the Commissioner and Secretary, Environmental Control, was asked to produce a report on the measures needed to clean up the waterways in Madras City. The working group delegated the responsibility to the following sub-committees: (1) Sub-committee on colonies and encroachments on the banks of the waterways; (2) Sub-committee on sewerage and stormwater management; and (3) Sub-committee on future uses of the waterways. INTACH representatives participated on each of the sub-committees in order to provide input into different aspects of management of the waterways. The sub-committees produced draft reports which were provided to the Secretary (Environmental

Control), who consolidated them into a final report which was submitted to the Chief Secretary, We will discuss the contents of this report in the next chapter.

Preliminary Evaluation of the Campaign:

The "Citizens for Clean Waterways" campaign was the first major environmental project undertaken by the Tamil Nadu Centre of INTACH. The campaign was also the first of its kind in Madras City, and experienced both the advantages and disadvantages of a pioneering effort. The signature drive and the one rupee collection per individual, kept the cost to the individual as low as possible, in terms of participation. (If the individual were to join INTACH itself, he would have to pay an annual membership fee of Rs.50/-, and take the time to participate in various activities of the organisation). The campaign in comparison provides for more broad-based pariticpation at a lower cost. The token contribution of one rupee was meant to indicate a minimum level of committment. (Thiagarajan, 1986).

The campaign was launched in June 1986. During the first year, the number of signatures obtained was about half a lakh (i.e. about 5% of the target). The funds received amounted to Rs.79, 681 (or 7.9% of the target). In January 1988, a decision was taken to intensify the campaign to keep the issue alive in the minds of the citizens. Despite various political developments that occurred during this period, a massive signature drive was launched at over 50 centres with the assistance of NSS volunteers, banks and many other voluntary organisations. The other organisations suggested that the monetary contribution be dropped. The total number of signatures collected was around 2 lakhs (about 20% of the target). Thus, the programme has made a significant beginning, but will have to be sustained over a longer period to achieve some of the stated goals. However, the goals may have been ambitious, and may have to be scaled down if the same level of interest cannot be sustained.

"Citizens for Clean Waterways" is now a registered society, with a Board of Trustees, bye-laws, etc. Thus, an institutional framework is now available for sustained effort, and for seeking adequate finances to implement an effective programme.

Thus, INTACH has used the signature drive to initially overcome the "free rider" problem by lowering the cost of participation to the citizen. It has also used various environmental education programmes to create awareness about pollution of the waterways. The rallies and other public events were covered by the newspapers, popular magazines and television. Thus, a large number of individuals are aware of the "Clean Waterways" campaign, although they may not be familiar with INTACH. The clean up programmes announced by the Government at various times, including the 1988 budget speech of the Governor, has also sparked the interest of Madras City residents.

The relationship of INTACH with the Tamil Nadu Government has been rather complex. The campaign was launched (in June 1986) with a Minister of the State Government present. The then Chief Secretary took a personal interest in the issue and organized an inter-agency task force. As mentioned earlier, four from INTACH participated on the task force. However, after the deliberations of the group concluded in December 1986, the issue was "put under wraps" by the State Government. Occasional announcements were made by various ministers and bureaucrats, throughout 1987, regarding a proposed clean-up project. However, INTACH's involvement was not solicited until September, 1988. The reason cited was that negotiations were underway with the British Overseas Development Authority for financial and technical assistance for the clean up project.

At this point, it would be useful to evaluate the success of campaign using the public participation criteria suggested by Krimsky:

1) The involvement of citizens in a government task-force on cleaning the waterways was a major success story of the campaign. The traditional decision-making process in the area of water management tends to be relatively closed to the general public. The fact that INTACH representatives were allowed to provide input to the sub-committees, and thereby to the final report was a clear indication of access to the decision-making process. However, the involvement of INTACH has not extended beyond this stage at present.

Various officials of the Tamil Nadu Government have raised the issue of cleaning the waterways at different forums. They have also talked about the need to receive assistance from the Centre or from international agencies. However, there has not been much public discussion by the Government of the details of such a programme, at the time of writing.

2) While various opinions were solicited by the task-force, no effort was made to analyse the various options. Implementing agencies were asked to provide a set of recommendations which were incorporated into the final report. No serious effort was made by the task-force to identify and analyse merits of different options.

3) The people who would most immediately be affected by a clean-up effort would be the slum dwellers, who live on the banks of the three waterways. Although, they did not have their own representative on the task force, their interests were represented, atleast in part by the Chief Engineer, Tamil Nadu Slum Clerance Board. Also, one of the sub-committees made a serious attempt to study the issue and, produced a detailed draft report.

4) As mentioned earlier, the impact on the slum dwellers was considered by a sub-committee. However, no effort has been made so far to solicit the views of the potentially affected communities (around 20000 households) regarding various options. For most of the slum-dwellers who live on the banks of the waterways, any effort at improvement would necessitate relocation. The relocation of these households would be expensive, both economically and politically. While various schemes have been considered by government agencies, the issue has not been taken up for public debate because it is deemed to be politically sensitive. However, no real solution is possible without participation of these low income households (Appasamy and Thiagarajan, 1987.

As is the case with many voluntary agencies in India, INTACH has been relatively more successful in environmental education and awareness programmes than in affecting the process of decision-making. However, access to decision-making is vital if INTACH is to have an impact on public policy. Public participation is crucial if the programme to clean the waterways is to succeed. In the next chapter, we will discuss various proposals that have been made for cleaning up the waterways, including the report of the task-force.

Chapter VIII

PLANNING FOR THE WATERWAYS: A PRELIMINARY EVALUATION

We will conclude this report with a brief description of various efforts to institute a process for water quality planning in Madras. As mentioned earlier, the problem of polluted waterways in Madras dates back to the turn of the century. Proposals to flush the Cooum with seawater were considered more than fifty years ago. The unsuccessful Cooum Improvements Scheme was attempted twenty years back. Consequently, Madras city residents have a sense of "deja vu" about any scheme to clean the waterways. Like the poor, the waterways always seem to be with us. Madras would not be Madras without the stench of the Cooum and the Buckingham Canal!

But, as we have argued strenuously in this report, the pollution of the waterways has costs- in terms of health, ecology, and, more significantly in terms of wasted resources. Opportunities to use the waterways for recreation, navigation, etc. are lost. Opportunities to use the nutrients in the wastes, or reuse effluents in a chronically water-starved city are lost. Thus, engineers, planners, administrators, scientists, and the enlightened citizenry of Madras have continued to press for improvement of the waterways. This interest has resulted in a spate of proposals - most of them at the technical level. A few have been subjected to rigorous analysis. We will discuss three of these proposals in the first part of this chapter.

Next, we will discuss the water quality planning process initiated by the then State Government, as a result of the prodding done by various interest groups. This planning exercise has followed some but not all of the principles that were enunciated in the previous chapter. We will not discuss the process as such, since we have already done so in Chapter VII while

describing the Clean Waterways Campaign. We will focus greater attention on the report itself, and, provide a brief evaluation of it.

In the last section, we will make some recommendations to build on the foundations for planning that have already been laid. In particular, we recommend that a management agency coordinate the planning and implementation in a phased manner. We also suggest a more "open" planning process that will permit a greate degree of public participation.

Substantively, we argue for a greater allocation of resources for pollution control, as compared to flood control, navigation, and other planning objectives. The basic premise that underlies this entire report is that "wastes" are resources which are at the wrong place at the wrong time. If they can be managed properly, they will produce a stream of continuing benefits. Therefore, our first priority should be to restrict the quantity of wastes from ever entering the waterways. Any residual wastes which we cannot control can be treated through flushing, dilution, aeration, or biological action. Only then will the waterways be more suitable for positive uses such as recreation, navigation, etc. Thus, resource allocation must be based on prioritization of objectives, both in terms of resources allocated, as well as in the sequencing of activities.

A. Proposals for the Waterways

We will discuss proposals made by:

1). Indian Institute of Technology, Madras
2) Zoology Department, University of Madras
3) Tamil Nadu Intellectuals Forum, Madras

There have been many ideas and suggestions mooted by different individuals at various times. However, the above proposals were made as a result of some amount of analysis, and are not merely "expert" opinions or commonsense solutions. The respective authors have also spelt out their proposals in some detail on paper. (The full I.I.T. report was not made public, but a

summary was available). We will discuss each of these briefly.

1) <u>The I.I.T. Proposal</u>

The centre piece of this proposal is the building of a breakwater (or groyne) south of the Cooum mouth, so that the "littoral drift" (of sand) does not result in the formation of the sand bar. Studies were undertaken by the Oceanography Department in consultation with the Institute for Hydraulics and Hydrology, Poondi. There has been some concern about the effect that such a breakwater may have on the port, which is on the northern side of the river mouth. The proposal has been referred by the Government of Tamil Nadu to the Central Water and Power Research Institute in Pune.

Other elements of the I.I.T. proposal include

a) discharging coolant water from the Ennore thermal station into the adjacent Buckingham Canal, to be carried South into the Cooum to improve flushing.

b) Reduction of pollution from sewage and other sources into the river (Sastry, 1987).

While there is some discussion of pollution reduction, the <u>major</u> emphasis of the I.I.T. proposal is on "flushing" (by the sea if the sandbar is removed, and by cooling water from the thermal station).

2) <u>The Zoology Department Proposal</u>

The Zoology Department, University of Madras has carried out a number of studies of pollution of the Cooum. We have referred to some of these studies in Chapter III. There are two major conclusions resulting from these studies:

a) The removal of the sandbar is critical in terms of providing dissolved oxygen to the estuary. i.e. No biological life is possible in the estuary otherwise (assuming that the current levels of pollution continue).

b) If there is adequate dissolved oxygen, it is possible to culture a species of filter - feeding shellfish, Perna Viridis which can ingest and accumulate pathogens and particulate matter from sewage.

These conclusions have led to suggestions of the following remedial measures:

i) Removal of the sand-bar using manual labour and/or mechanical dredgers.

ii) Pumping of fresh sea water/ground water in pipes laid along the Cooum bank upto Harris bridge.

iii) Construction of groynes/pier/breakwaters at a location South of the Cooum mouth.

iv) Removal of organic and other pollutants by using the accreted sand as a filter bed

v) Biological treatment of the Cooum estuary involving the use of exotic culturable species such as Perna Viridis. (Azariah and Azariah, 1981).

Suggestions (i) and (iii) rely on the flushing action of the sea (through tidal action) to clean out the pollutants, and provide adequate dissolved oxygen. Suggestions (iv) and (v) involve treatment of the river itself by filtration and biological action. Engineering evaluations of suggestions (iv) and (v) have not been done, so their economic viability and technical feasibility is not known. Suggestion (ii) has a long history (Srinivasachari, 1939). The Public Works Department is doing an evaluation of pumping seawater much further upstream to Koyambedu.

c) The Tamil Nadu Intellectuals Forum Proposal

This proposal was prepared by Mr. T.B. Bharathi, I.A.S.(Retd.) and submitted to the Forum for endorsement. A Summary of the proposal was also published in "The Hindu". While there were many elements in

his proposal, the following are the key aspects.
i) Using coolant water from the Ennore thermal plant for flushing (similar to the I.I.T. proposal)
ii) Pumping 100 cusecs of seawater to a point 2 km east of the entry point of the Cooum into the City., The capacity of the pumps needed is estimated at 3000 H.P. In addition there would be anicuts with sluices to hold the water at a level of 5' in the river, except during times of flood. A lake will be formed near Napier Bridge. The surplus water will be used to flush the South Buckingham Canal.
iii) Both the Cooum and the Buckingham Canal will be made navigable.
iv) The bed of the Cooum will be lined with polythene sheets to prevent intrusion of brackish water into neighbouring aquifers. It is estimated that the cost of this proposal would be around Rs.40 crores (Bharathi, 1987)

The central element of this proposal is the pumping of seawater for flushing the Cooum and part of the Buckingham Canal. An interesting aspect of the proposal is the navigability objective. As mentioned earlier, the PWD is evaluating the feasibility of pumping sea-water to the upper reaches of the Cooum.

Each of these technical proposals need to be evaluated carefully in terms of technological feasibi-lity and economic viability. However, the prepon-derant emphasis is on systems for "flushing" or dilu-tion. While alternatives of this kind are needed, it is necessary to view the problem in a comprehensive manner. Specifically, the following aspects should be considered in planning.

1. It is preferable to reduce pollution at the source, rather than dilute, flush or transport it to the sea. The first priority, therefore, is to reduce the dis-

charge of offluents - sewage, urban runoff, sullage and industrial waste into the waterways. The 1968-72 scheme was unsuccessful largely because the emphasis was placed on physical improvement of the river and the banks rather than on control of sources of pollution.

2. In a water scare city like Madras, we must conserve as much water as possible and not promote discharge into the sea, i.e. we must use a circular, not a linear concept in planning. This goal can be achieved only by transporting sewage and urban drainage to efficient sewage treatment plants where the water can be separated from the sludge and reused. The sludge could be used in growing grass for fodder, or could be used to generate biogas. Treated effluent coule be used for industrial purposes or for maintaining minimum flow in the waterways.

3. While the sea is often thought of as a convenient sink for waste disposal, we must recognise that we gain little in reducing river pollution by increasing marine pollution. In particular, the close proximity of the mouth of the Cooum to Marina Beach is an indication that we must not promote discharge of wastes into the sea. Not only will the marine ecosystem be damaged, but so will a major natural resource - the beach. However, flow condition in the river must be maintained to prevent stagnation in the estuarine region. Otherwise, there is an accumulation of pollutants which damages the estuarine eco-system and is also a threat to public health. The removal of the sand-bar at the river mouth either by dredging or by other technological means remains an important priority.

4. We must also recognise that the waterways are flood-carriers during the monsoon season. We must find some means of conserving flood waters, so that they can be utilised more effectively during times of drought.

5. Pumping seawater into the Cooum (Proposals 2 and 3) involve enormous continuing energy costs. Mr. Bharati estimates that pumping seawater will cost Rs.1.3 crores annually in terms of electricity costs. In a power-short State like Tamil Nadu, we would have to closely examine the merits of using so much energy for this purpose.

In summary, we must not only look at engineering goals but also at environmental and energy goals. These include preserving the marine ecosystem, utilising resources such as the waterfront and the beach more effectively, improving environmental health sanitation, increasing visual and aesthetic enjoyment, etc. Not all of these are measurable in monetary terms. But, we must find ways of incorporting these intangibles in the evaluation of the alternatives.

B. The "Master Plan" for the Waterways

In Chapter VII we described the circumstances which led to the creation of a Governmental Taskforce on the Waterways. The taskforce was established in October, 1986, and, presented its report to the Chief Secretary, Government of Tamil Nadu, two months later. A copy of this report was made available to members of the task-force, including the non-governmental representatives. Subsequently, the planning exercise was carried on "in camera", except for occasional pronouncements and news stories in the Madras dailies. The original taskforce report recommended the expenditure of Rs.77.77 crores for cleaning up the waterways. Subsequent, news items mentioned a figure of Rs.194.14 crores. "The Hindu" published a detailed story on March 27, 1988, providing a breakdown of the costs. In addition to the original estimate, there were two major items of expenditure: 1) Relocating the slum dwellers

who live on the banks (Rs.62.53 crores) 2) Laying stormwater drains to the full length of roads (Rs.53.3 crores). Some additional sewerage improvements costing Rs.0.54 crores were also included, bringing the total to Rs.194.14 crores. This figure has been mentioned frequently by the Government. The news story also mentioned that the British Overseas Development Administration (ODA) had been approached for both financial and technical assistance (The Hindu, 1988)

The taskforce report entitled "Environment Protection in Madras City - Problems and Perspectives", provides a good outline of environmental problems in Madras (19 separate issues are mentioned) in the synopsis. But the rest of the report is essentially a Public Works Department (PWD) Work Programme. To quote,

"This brief report confines itself to the limited aspects of the following measures (by the Irrigation Wing of the PWD):

i) Moderate floods in the Cooum and Adyar Rivers.

ii) Prevent pollution and degradation of water courses.

iii) Provide water circulation for Cooum by flushing by suitable engineering works.

iv) Revive the Buckingham Canal and use it effectively for inland navigation" (Taskforce Report, 1986).

In the Synopsis, the report also recommends:

"The creation of an authority clothed with suitable powers to plan, co-ordinate and monitor the approach, attitudes, methodology, performance, activities, and management of the varies agencies" (Taskforce Report, op.cit.).

The Government has since made no mention in any of its pronouncements about the creation of any authority for managing the waterways. We will merely note that this recommendation of the taskforce is consistent with the institutional principles that were laid down in the last chapter. We will not repeat all the reasons in support of this proposition.

Although the report claims to deal with flood control, pollution control and navigation, the emphasis on pollution control is indeed very small as we shall see later. The expertise and background of the PWD is largely in water quantity management and not in water quality management. This difference in emphasis is reflected in plan formulation.

Apart from the Synopsis and the Conclusion, there are four chapters devoted to each of the four waterways. viz. the Cooum River, the Adyar River, the Buckingham Canal and the Otteri Nullah (a small drainage channel which flows into the Buckingham Canal). These descriptive chapters provide a good qualitative description of both the water quality and water quantity problems. However, in the concluding chapter, the works proposed to be taken are almost all flood management or flow management measures with little emphasis on water quality. (The items added on later were mainly the relocation costs and the costs of stormwater drainage).

We need to study the works proposed for each of the four waterways to explain the approach recommended in the report.

a) The Cooum River : Of the eight works mentioned, one has been sanctioned, and one is still under review by the PWD

Works	Estimated Cost	Percentage
i) Improving the right flood bank	Rs. 7.40 lakhs	
ii) Strengthening the left flood bank	Rs. 5.45 lakhs	
iii) Diversion of floods to Poondi reservoir	Rs.377.00 lakhs	
iv) Improvement to 8 tanks in Cooum basin	Rs. 30.00 lakhs	
Subtotal - Flood Control Works	Rs.419.85 lakhs	27.6%
v) Beautification within the city	Rs.309.14 lakhs	
vi) River improvements from Aminjikarai to Chetput	Rs.157.30	
Subtotal-River improvements	Rs.466.44 lakhs	30.7%
vii) Clearing shoals and silt upto the mouth	Rs.125.00	
viii) Pumping of seawater to Koyambedu for flushing	Rs.510.00	
Subtotal-Pollution Control Works	Rs.635.00 lakhs	41.7%
Total	Rs.1521.29 lakhs	100%

The major means of pollution control suggested in the report involves pumping seawater, if it is technologically feasible. However, its major limitation is that it merely transports the wastes more efficiently

to the sea, without the current problems of stagnation. It does not address the issue of waste reduction and utilisation. Even the pollution control objective is handled by increasing the quantity of water. The works suggested for the other waterways do not exhibit even this limited concern for water quality.

b) The Adyar River: Seven works are suggested - two are sanctioned, four are proposals (with the government), and one is under consideration by the PWD;

Works	Estimated cost	% Cost
i) Providing flood protection (phase I)	Rs. 200.00 lakhs	
ii) Diversion of floods to backwaters	2860.00 "	
iii) Improvements to 9 tanks in Chembarambakkam group	20.00 "	
iv) Providing flood protection (phase II)	1100.00 "	
v) Building a flood protection wall near the estuary	3.60 "	
Subtotal - Flood Protection	4183.60 lakhs	98.24%
vi) Subtotal - River improvements	70.40 "	1.65%
vii) Subtotal-Pollution Control (Removal of Sand bar)	4.50 "	0.11%
Total	4258.50 "	100.00%

Thus it is apparent that almost the entire cost (98.2%) is allocated for flood protection.

c) The Otteri Nullah: There are three works - one sanctioned, one with the government, and one under consideration.

		%
Flood Protection	Rs. 72.00 lakhs	74.77
River Improvements	Rs. 22.00 "	22.84
Pollution Control (Removing shoals)	2.30 "	2.39
Total	Rs. 96.30 lakhs	100.00

We note once again the major emphasis on flood protection and physical improvements.

d) The Buckingham Canal: There are currently no works sanctioned, four proposals are with the Government, and three others are under consideration by the PWD.

Works	Estimated Cost	% Cost
i) Improvements to North Buckingham Canal (from Chintamani to Ennore)	Rs. 200.00 lakhs	
ii) Improvements to North Canal (from Ennore to Elephant Gate)	Rs. 128.50 "	
iii) Improvements to South Canal (from Adyar to Mahabalipuram)	Rs. 502.00 "	
iv) Improvements within City limits	Rs. 155.00 "	
v) Improvements to North Canal (from Chintamani to Tamil Nadu border)	Rs. 300.00 "	
vi) Improvements to South Canal (Mahabalipuram to Marakkanam)	Rs. 600.00 "	
Subtotal Canal Improvements	Rs. 1885.50 lakhs	99.2%
Pollution Control (Desilting from Ennore to Central Station)	Rs. 15.00 lakhs	0.8%
Total	Rs. 1900.50 lakhs	100.00%

Since a major objective is to revive the navigability of the Buckingham Canal, resources have to be allocated for this purpose. However, assigning 99% for improvements without any attention to all the assorted wastes entering the canal seems strange. Also the allocation of Rs.9 crores (items V and VI) out of the Rs.18.85 crores for improvements outside the Madras Metropolitan area is not consistent with the regional objective. In fact, of the six improvement proposals, only item (IV) costing Rs.1.55 crores is actually within the city. A regional approach could include (i), (ii) and (iii), since there are major benefits to the metropolitan area. However, (V) and (VI) are clearly not of any concern in a regional plan. The Buckingham Canal is 420 Km long, and any effort to make the entire length navigable should be considered under a separate inter-state scheme. But, the more serious lacuna in planning is the virtual lack of emphasis on water quality.

If we combine all the schemes by objective rather than by waterway, we get this overall picture.

Objective	Estimated Cost (in crores)	% Cost
Flood Protection	Rs.46.75	60.11
River Improvements	5.59	7.19
Canal Improvements	18.86	24.25
Pollution Control(Pumping seawater)	5.10	6.56
Pollution Control(Removing shoals)	1.47	1.89
Total	77.77	100.00

We note that the pollution control objective has been allocated only Rs.6.57 crores (8.45% of the total), whereas water quantity projects such as flood protection and river/canal improvements account for 91.5% of the works. While one does not wish to discount the importance of flood protection and other related

works, the allocation of resources is not based on prioritisation of objectives. Even in the case of flood protection, there is no discussion either in the text or in the allocation of resources for improved land management. It makes no sense to continue to build on the flood plains of the waterways, and, then provide expensive flood protection measures. This is particularly true of the Adyar, where the possibilities for severely restricting land development is still possible. The proposals to improve tanks in the Adyar and Cooum basins are to be commended. However, only 50 lakhs (Rs.0.5 crore) has been allocated for this purpose. The text of the report also recommends that "all the tanks in Madras City should be maintained to the required standards, to protect the Buckingham Canal". However, no funds have been allocated for this purpose.

The water supply objective is considered in only one scheme which involves the construction of a channel from Tiruvallur to Poondi to reduce flooding problems of the Cooum. According to the report " it would incidentally augment city water supply"! In a city which has suffered the ravages of drought for a decade or more, and where evacuation plans have been seriously considered on account of water scarcity, the almost cavalier attitude about the importance of water supply, underscores the mission-oriented approach of the PWD.

However, in fairness we must reiterate their qualifier at the beginning of the report, that the report was confined to those limited aspects within the purview of the PWD. It was the failure of the taskforce, and in particular its Chairman, to merge the report of the PWD with the reports of other agencies in order to deal with various aspects of the waterways. Instead, the PWD report was accepted in toto, and presented as the report of the Taskforce. The other later additions to the

PWD proposals were the massive relocation proposal of the Slum Board and the stormwater drain proposal of the Corporation. We will discuss each of these proposals as well.

As mentioned earlier, the master plan for the waterways has basically three major components and one minor component.

1) The PWD proposals for the waterways	Rs.77.77 crores	40.06%
2) Relocation of slum households	Rs.62.53 "	32.21%
3) Stormwater drains for the city	Rs.53.30 "	27.45%
4) Additional Sewerage improvements	Rs. 0.54 "	0.28%
	Rs.194.14 Crores	100.00%

Since we have discussed the PWD proposals at some length, we should also comment on the other major elements of the package.

According to the taskforce report, there are 20,500 slum households living on the banks of the waterways 9500 (Cooum - 4250, Adyar - 3800, Buckingham Canal - 9500, Otteri Nullah - 2950). Providing alternative accomodation/land for 11,750 of these households would cost Rs.62.53 crores.. i.e. approximately Rs.53,217 per household. Thus the cost of acquisition of about 250 hectares of land in the master plan for the waterways, includes a "defacto" low-income housing plan. If we assume an average of 5 persons per household, the relocation involves about a lakh of people or roughly 10% of the entire slum population of Madras City. We have already discussed the pros and cons of relocation in our discussion of social issues in Chapter V. We have made a case for compensation (in terms of housing or cash), because there are water quality benefits that will result; eviction should be avoided at all costs.

However, we may also wish to consider if on-site improvements in terms of sanitation, etc. can be provided in some of the cases. This alternative may reduce the overall costs of relocation. Also, since the scale of relocation is vast, it must be considered in terms of the overall housing policy for the City. For example, these residents could be given first preference on all new "sites-and-services", and other low income housing projects. Since, they would acquire a long term asset, it may also be desirable (based on their ability to pay) to ask them to share the costs of relocation. It is highly unlikely, that any funding agency will provide Rs.62.53 crores with no provision for cost-sharing and/or repayment.

The stormwater drains proposal was based on the rather simplistic notion that drains were needed for every paved road in the City. Since it costs an average of Rs.10 lakhs per km of drain, and there are 533 km of roads without drains, the total cost of the proposal was estimated to be Rs.53.3 crores.

There is no doubt that there are severe drainage problems all over Madras City during the monsoon season. The problems of stagnant water, the health risks due to mosquito breeding, etc. have been referred to earlier. However, building a complete network of drains poses a number of problems:

1) If there is no treatment at the terminal point, the drains contribute to the pollution of the waterways. Additional 533 km of drains will result in greater (not lesser) water quality problems. The drains serve as a convenient means of dumping garbage, cattle wastes, and for connecting house/institutional sewers. Street surface contaminants are washed into the drains and ultimately into the waterways.

2) During heavy rains, water is quickly channelled from the streets into the drains and ultimately into the waterways. The probability of increasing (not decreasing) flooding of the waterways will result from having more drains.

3) The rapid movement of water from the streets into the drains will reduce the possibilities for percolation and groundwater recharge. In a city, where more than a million people depend on groundwater, we should be finding various means for augmenting(not reducing) the stock of ground water.

Thus, building more stormwater drains may worsen water quality, increase the risk of flooding, and decrease the recharge of groundwater - i.e. a violation of three major planning objectives. On the other hand, it reduces the amount of stagnation in low-lying areas. We, therefore have to balance these fac tors, and, not base our planning on the simple premise that Madras needs more storm water drains.

Clearly, low-lying areas and flood plain developments require a system of drains. But, we can also think creatively in terms of holding stormwater in tanks or ponds, that are cleaned periodically and are sprayed for mosquitoes. These sedimentation ponds can diminish pollution loading and flooding risk simultaneously. Also, in planning future developments, low-lying areas and tanks can be mainatined for this purpose, rather than indiscriminately filling them up. Historically, hydrological irrigation management relied on such systems of tanks. There is no good reason why a similar logic cannot be used for stormwater management in an urban context. Cities like Chicago which are highly urbanised have built multi-billion dollar tunnel system to hold stormwater to avoid both pollution and flooding.

we can learn from the difficulat experences of other cities, and, avert problems before they occur, by falling back on our historical systems of tanks. Our chronic watersupply shortage can also be partly alleviated, if we can hold more of our storm water. The allocation of only Rs.0.5 crores out of Rs.194.14 crores for tank improvements in a sad reflection of our sense of priorities, especally when Rs.53.3 crores are allocated for stormwater drains.

In summary, the "master plan" represents an almost exclusively engineering approach to the problem of the waterways. Scant attention is paid to environmental, ecological or human considerations. None of these solutions (with the possible exception of relocation) will lead to better water quality - supposedly, the major objective of planning. The stormwater drains could actually end up adding to the pollution load of the waterways. The one engineering programme which could improve water quality significantly, namely sewerage improvements, is allocated only Rs.0.54 crores. The argument given is that sewerage improvements are funded elsewhere by the Central Government. But, the point is that a water quality plan for the waterways must be comprehensive, regardless of the source of finance for various elements in the plan. Only then can we delineate interrelationships, formulate strategies, etc. in a meaningful fashion. It becomes particularly important when we deal with issues of management and coordination. If we address each major issue separately, the programmes will not be synchronized and we may end up wasting resources. This was in part the experience in 1967-72. While the PWD made river improvements, pollutants continued to pour into the waterways, ultimately negating all their efforts.

The taskforce report has the potential for repeating history. There is no doubt that technological solutions are needed. But, this is only <u>one</u> step of the overall planning process that we described in the last chapter. The report contains no discussion of water quality goals; has limited consideration of interrelatinships; has surprisingly little discussion of technical <u>options</u> (the "works" proposals were not considered in competition with other alternatives); has no discussion of management aspects, except for the recommendation of a coordinating agenty; makes no effort at cost-effectiveness analysis or of any other evaluation criteria. The report is simply presented as a plan of action. Apart from including INTACH representatives on the taskforce and then excluding them from further deliberations, there was little public input in the preparation of the Plan. In short, the process fell far short of the ideal planning process.

On the other hand, the creation of the taskforce, and, the inclusion of non-government representatives was atleast one step towards a more <u>rational</u> process for planning and management. In this sense, these pioneering attempts are to be applauded and encouraged, and could well serve as a foundation for better planning. In our final section, we will make further recommendations for building on this foundation.

<u>C. Recommendations</u>

In addition to the efforts made by the Government uptil the present, the following suggestions could be considered to improve the planning process for the waterways.

1. Lead Agency

It is vitally important that a "lead agency" be designated by the Government to coordinate the planning, management, execution, and review of the project. The "lead agency" should preferably be regional because the project must be envisioned in regional terms. The agency should also have some accountability to the public during and after implementation. This project must not be considered as a "works" project which is executed and then forgotten. There should be continuity in planning and implementation. The agency must have the technical competence in water quality planning and management.

The only agency that meets these requirements is the Madras Metropolitan Water Supply & Sewerage Board ("Metrowater"). Metrowater is a regional agency that has important water - related functions. It also has the necessary planning capability. It has demonstrated the ability to work to a clearly conceived plan of action in both the water supply and sewarage areas. It also has the statutory responsibility (under the Madras Metropolitan Water Supply and Sewerage Act) for water pollution control in the Madras Metropolitan Area.

While various "works" undertaken might be implemented by the PWD and other agencies, the coordination of these efforts must be the responsibility of "Metrowater". The only exception we would make is stormwater drainage. We would recommend that stormwater drainage be transferred from the Madras Corporation to Metrowater. It makes little sense to separate the systems for underground wastewater (sewerage) and overground waste water (drainage), particularly when there are so many interconnections between sewers and drains.

More importantly, the current planning for stormwater management is deficient in a number of ways. The water quality planning capability of Metrowater is far superior, in terms of their understanding of pollution control. While treatment of stormawter may be a lower priority (at the current time) compared to treatment of sewage, the possibilities for the future must be studied. The interrelationships with water supply, flood control etc. require careful consideration. There is little expertise in the Corporation to do such studies.

2. Monitoring Agency

While Metrowater has the technical competence to coordinate the planning and implementation, it is important that an independent agency monitor this process. The monitoring agency must have the technical competence to compute waste loads, measure water quality and conduct impact studies. The only agency that currently has this capability is the Tamil Nadu Pollution Control Board. (TNPCB). Furthermore, it has the statutory responsibility under the Water Pollution Act (1974) and the Environmental Protection Act (1986) to control pollution of the waterways. Thus, the TNPCB can carry out the necessary studies to determine the sources of pollution (sewage, sullage, industrial wastes, etc.), the contribution of each source, and the extent of control after implementation. They can also perform water quality studies, before and after implementation, to gauge the level of improvement.

It is amazing that the taskforce did not suggest any means for controlling industrial wastes, although the report mentions more than once that untreated industrial wastes are polluting the waterways. We have referred earlier to an estimate of about 1.5 million litres per day of industrial wastes that are entering

the waterways (Nammalwar, 1987). These wastes are from industries such as electroplating, plastics, batteries, electrical goods, textiles, chemicals, paints pharmaceuticals, refin eries, power stations, etc. There are reports of bioaccumulation of heavy metals such as mercury, cadmium, copper, nickel, lead and iron (Nammalwar, op.cit) and of toxic concentrations in water collected from the waterways (Anantaraj et al, 1986). Planning for the waterways must include strategies for limiting the discharge of toxic and conventional pollutants by industries. The Pollution Control Board has the statutory responsibility for regulating these dischargers. Thus, the TNPCB can play a key role in monitoring and in regulation. The Board can also ensure that Metrowater itself meets water quality standards, by proper treatment of sewage.

3. Policy Planning Committee

It is recommended that the taskforce (with some modifications) be made a standing committee. The Committee could provide policy perspectives to the lead agency, and other implementing agencies. The Policy Planning Committee (PPC) could also have citizen representatives who could provide public input into the planning process. These need not be restricted to INTACH representatives. There must be a way for the PPC to solicit the views of those affected by the project - i.e. those who live on the banks of the waterways. This could be done either directly or through the "Citizens for Clean Waterways". The Slum Clearance Board or MMDA can provide only a government perspective on the feelings of the slum dwellers. It would be preferable to have either a voluntary organization or representatives of the slum communities present their views to the PPC. "Eviction" must be avoided at all costs. Although differences in perception may exist, these must be resolved to the satisfaction of the affected parties.

The PPC can also help to resolve conflicts in objectives, conflicts among agencies, etc in an open uninhibited way. Many of these conflicts may be due to value differences, and, need to be aired in a public forum. Restricting discussion and carrying on deliberations "in camera" will result in the project being sabotaged by an aggrieved agency or group. There is no benefit in the long run in sweeping differences of opinion under the carpet. While a deliberative process may seem inefficient and take a longer time to implement, it will result in a project that will do the greatest good to the greatest number of people.

One of the major tasks of the PPC is to obtain some consensus on objectives. Planning cannot be carried out without clear delineation of objectives. "Cleaning up the waterways" is too vague - it has to be translated into some measurable objectives of water quality, flood control, etc. The objectives may have some "built in" incoonsistencies, but atleast these must be recognised so that conflicts can be resolved by making suitable trade-offs during the planning process.

The PPC would also be responsible for the hiring of technical and management consultants, with the lead agency providing staff support. The terms of reference for the consultants must be decided by the PPC. These are the ways by which the planning process is made "open". There is transfer of information from the government to the public, and, in the reverse direction through public input to planning. The PPC of course, always has the freedom and the authority to choose among the options.

Environmental problems are societal, not individual, and, therefore attention should be focussed largely on social choice rather than private choice (Mc Inerney, op.cit). Thus, we must create an institutional frame-

work such as the PPC that facilitates the process of making social choices. While we cannot poll every individual in Madras on his preferences regarding the waterways, we must use some mechanisms that will reflect these preferences in a meaningful fashion. We also know that we cannot aggregate preference orderings, but we can atleast discuss these in a public forum, and try to seek consensus.

4. Technical Review

A large number of technical options have been suggested by various individuals and organisations. The appropriate planning process is to evaluate these options based on planning objectives, technical feasibility, cost-effectiveness/ social and political acceptability, etc. For example, wastewater reuse in industry may meet all the planning criteria. However, workers in industry may have some psychological problems about using wastewater. It will then be necessary to find out how this barrier can be overcome. Thus, it is necessary to avoid a purely "engineering" approach to planning. The selection of a mix of options has to be done by weighing the pros and cons. It would be most undersirable to present the strategy fait accompli, which is the case with most reports.

For this purpose, it would be useful to hire a consulting engineering firm (domestic or foreign) to provide a technical appraisal. In their terms of reference, they should be asked to evaluate the options considered by the PPC, to be worth pursuing. The consultant most demonstrate experience in water quality planning and management. The assistance of agencies such as the ODA may be useful in this regard, because they can evaluate the competence of foreign consulting firms.

Once the review has been completed, the PPC can take a final decision about an "optimal strategy". However, they would also ~~weigh to~~ take various management aspects into consideration. The recommendation could then be made to the government for sanctioning the necessary funds.

5. <u>Management Review</u>

The PPC must examine the legal, institutional and financial implications of the strategy. They might wish to consider the British model in establishing a regional planning approach. In Great Britain, legislation was passed in 1974 for the creation of regional water authorities (RWA). Each RWA has responsibility for water supply and pollution control, for the use of inland waters for recreation, land drainage, and flood prevention, and for fisheries in inland and coastal waters. The financing policy imposed a single residential change to cover water supply and sewage disposal. Charges wore also made for discharge of industrial wastes <u>into</u> muncipal sewerage systems, and for discharge of industrial and agricultural purposes, and for recreational use of water. Each RWA is self supporting with dependence on the Central Government only for loans for capital construction. (Whipple, op.cit) One of the success stories of regional planning was the creation of the Thames Water Authority which handled the water pollution and other water-related problems of Greater London.

The RWAs have to deal with technical and institutional issues, which are very similar to the ones faced in the current context. The RWA has boundaries following the river drainage basins, thus merging the physical boundaries with the institutional boundaries for more rational management. The Madras Metropolitan

Area contains the drainage basins for the Cooum and the Adyar to a great extent. Since the Buckingham Canal is a man-made canal which cuts across many river basins, we can only include that portion of the canal which is in the Metropolitan area. Improvements to the Canal in the MMA will have recreational and tourist benefits but not for long distance transport of goods and services. Those plans could be developed separately by the PWD for reviving the canal as an inland waterway. Thus, the MMA is the logical area for regional water quality planning.

In this task also, the ODA could provide assistance based on the British experience with RWAs. However, the legal, institutional and financial aspects may have to be tailored to the Indian context. The PPC could commission a local management consulting firm to provide an analysis of the management options.

6. Public Participation

We have already discussed the mechanisms for public input through the PPC. It is also important to explain these developments in a non-technical way to the general public. The "Citizens for Clean Waterways" is one of the organisations that can play this role of public education. Since there are many areas where citizens can assist by their individual actions, it is very important to enlist their support. These actions are in addition to any projects and programmes which government agencies might undertake. When we aggregate these actions over the entire city, they are not insignificant as far as the clean-up is concerned.

CCW and other voluntary organisations have a crucial role with regard to the slum dwellers who live on the banks. Historically, government agencies have not

shown a great deal of sensitivity to these situations, although these attitudes are changing. There is, however, an urgent need to handle this issue with sensitivity and caution. The sub-committee of the taskforce which worked on this issue should enlist the cooperation of selected voluntary agencies to study various options to relocation, and to implement them carefully.

7. Implementation of a Phased Programme

Assuming that a planning process is undertaken along the lines that we have suggested the last step is the delineation of a phased plan of action. Without preempting the planning process, the following guidelines are suggested. Prioritisation of work is absolutely crucial. In our judgement, the first priority should be the reduction in pollution loads entering the waterways. This strategy should be implemented in terms of five sub-plans:

(i). Plan for Sewerage Improvements - This should dovetail with existing Metrowater plans for the MMA. In particular, the discharges from unsewered areas, pumping station overflows, and from the treatment plants into the waterways must be highlighted. This plan must not be implemented independent of the overall master plan for the waterways.

(ii) Plan for Wastewater Reuse - the reuse of wastewater for industrial use, for truckwashing (in Koyambedu) and other possible applications including low flow augmentation must be accorded high priority.

(iii) Plan for Stormwater Management - The building of new drains, maintenance of old drains, possible treatment of storm water, refurbishing of tanks and holding ponds must be done in an integrated fashion. (It is not clear why this should constitute 27% of the budget, unless it is carefully planned).

(iv) Plan for Solidwaste Management - This plan must dovetail with the Corporation's solid waste management plans. Particular attention must be paid to collecting garbage which is now deposited on the banks. A review of plans to dump solid waste in low- lying areas (for land reclamation) must be done. Indiscriminate dumping causes pollution of groundwater, and, also decreases the potential for holding stormwater/increasing ground-recharge. Attention must also be paid to the disposal of sludge from treatment plants.

(v) Plan for Industrial Waste Management - Control measures for discharges of industrial liquid and solid wastes into the waterways must be given a high priority Possibilities for pre-treatment of industrial wastes prior to discharge into the municipal sewerage system might be considered. Peak efficiencies of municipal plants are achieved by mixing industrial wastes with municipal wastes, so long as there is pretreatment to remove toxic materials (which might harm the biological medium used in treatment).

At the next level of priority is the need to remove the sand bars at the mouths of the Cooum and the Adyar. We would accord this a lower priority compared to pollution reduction because we do not want to communicate the impression that "flushing" is the major strategy for pollution control. Rather, we would like flushing through tidal action to occur to maintain flow, and prevent stagnation at the estuary. But, we would like waste loads to be reduced to the maximum possible extent <u>before</u> we resort to flushing. Otherwise, all the wastes will end up in the sea ultimately contaminating the beach, the coastal fisheries, and the marine ecosystem. (We would <u>not</u> recommend pumping seawater unless it is found to be cost-effective).

Plans for relocation and/or making on - site sanitation improvements should be considered only at this point. Again, we do not want to communicate the impression that the slums are the major contributor of pollution loads to the waterways. However, they are a <u>marginal</u> contributor and control of their effluents must occur <u>after</u> the effluent of other major sources have been controlled. As mentioned earlier, we must consider various cost-effective options other than relocation. We do <u>not</u> recommend making the waterways master plan a massive low-income housing plan. Any relocation (if it is the last option) must dovetail with <u>existing</u> sites and services or other EWS housing plans. The existing allocation for housing (32.2%) in the master plan is simply too large, and must be restricted to 10% or less of project costs.

The next priority after pollution reduction, sandbar removal and slum improvement/clearance should be river management. There are a number of different measures which can be undertaken. These include physical improvements such as removal of shoals and silt, excavating drainage channels, etc. They also include treatment options for the river such as mechanical aeration, biological treatment etc. But, these treatment options must be considered only in the context of <u>residual</u> pollution. They are meant to take care of only the final 5-10% which is very expensive to treat in conventional waste treatment. The combination of tidal action with these treatment techniques can make the estuaries viable ecological systems once again. Possibly, some of the mangroves may be able to reestablish themselves, and bird-life in the Adyar estuary will be restored.

Along with the river management works, some limited flood control measures could be considered. We would not recommend making the master/plan a flood control programme as envisioned by the government. We recognise that flood control is one of the objectives of planning, and, should be given some consideration.

However, there are other objectives such as water supply, low flow augmentation, fishing, recreation etc. which are better served by holding flood water, instead of diversion into the sea. Also, land management is as important as building flood walls in controlling floods and needs careful consideration. The flood control programme for the Adyar (Rs.42 crores out of a total of Rs.47 crores for all the waterways) must be reviewed more closely. Land management and improvement of tanks could be accorded a higher priority compared to building expensive flood walls. There is no need to burden the master plan with many of these expensive projects. For example, it is not clear if the best option is spending Rs.28.60 crores on a flood diversion channel to the backwaters, given that there is far greater need to hold flood waters for water supply. It may be preferable to implement parts of the Phase I and II works for the Adyar after review. A cost-effectiveness analysis must be carried out for alternative flood control measures.

The next priority is the navigation improvements to the Buckingham canal. Here again, the cost of improvements can be cut in half by restricting it to the MMA. i.e. the cost would be Rs.9.9 crores rather than Rs.18.9 crores.

The last priority should be beautification, providing recreational facilities, introducing tourist

programmes, etc. The PPC must resist the temptation of putting these cosmetic changes at the top of the the list. Although there will be a lot of public and media clamour for doing so, these uses of the waterways must not be considered until it is proved (through monitoring) that the waterways are safe for indirect human contact. This is probably the most important lesson from the 1968-72 Cooum Improvements Scheme.

The role of the PPC and the lead agency are crucial in implementation. The PPC must protect the lead agency and other agencies from political and extraneous pressures. They must work to a plan, if the plan is succeed. If priorities are reversed, there might be some short-term benefits, but the project will be doomed after utilising a substantial amount of resources. It would have been better not to have attempted the project in the first place. Since water quality management is a complex and expensive undertaking we would recommend that an orderly planning process be instituted to increase the probability of success. But, planning for the waterways is a worthwhile undertaking because there are significant benefits in the long run, for both current and future residents of the Madras Metropolitan Area.

EPILOGUE

Since the preparation of this report, there have been further developments with regard to the waterways. The Government of India sought technical and financial assistance from the British Overseas Development Authority (ODA). The ODA sent a pre-appraisal team to Madras in February 1988 "to assess the main causes of pollution (of the waterways) and to advise on cost-effective steps to control it".

Based on the study by the consultants, the ODA has offered technical assistance costing £800,000 (around Rs.2 crores), which will provide sixty man-mouths of consultancy under a "twinning" arrangement between the Government of Tamil Nadu and a U.K. water Authority over a three-year period. The terms of reference are <u>inter-alia</u>:

1) The creation of a suitable institution to coordinate pollution control and water supply measures in Madras.
2) The clearance of blockages from river months
3) The design, operation, and maintenance of sewage works.
4) The rerouting of (industrial) effluent away from Madras.

The assistance provided does <u>not</u> include or envisage contributions towards capital expenditures for pollution control proposals recommended by the consultants. Thus, the assistance provided is largely consultancy oriented, and, the implementation of the proposals has to be financed separately by the Government of Tamil Nadu.

The Governments of India and Tamil Nadu have accepted the proposal of the ODA, and, have created a technical cell within the State Department of Environment Control. The

technical cell is supposed to work closely with the ODA and the relevant U.K. Water Authority under the "twinning" arrangement for a period of three years.

The terms of reference of the technical assistance (to be provided by the ODA) clearly indicate the following:

(1) The key issue with regard to the waterways is pollution, and, not flood control, or other objectives.

(2) The only flow related problem that needs to be studied relates to the blockages at the river mouths (Cooum and Adyar). The concern here is also about pollution, in the sense that the blockage prevents sewage from being carried to the sea.

(3) The consultants also pointed out that "there are eight different departments involved in pollution control, that coordination between them is poor, and, that a management organisation must be created to foster and co-ordinate activities", i.e. the institutional aspect of managing the waterways is important.

(4) Technical assistance for upgrading the sewage treatment plants will be provided. The original proposal of the Tamil Nadu Government had virtually no funds for this purpose.

(5) It is necessary to reroute industrial effluent entering the Buckingham Canal, which ultimately enters the city. The original proposal did not discuss or include any funds for this purpose.

(6) The ODA proposal makes no mention of relocation of slum dwellers on the banks of the waterways.

Thus, the proposals made by the ODA only serve to reinforce the recommendations that we have already made in the last chapter, with regard to the technical aspects as well as the management/institutional aspects. That the Government of Tamil Nadu has accepted such an approach is an encouraging sign. When the consultants complete the technical work (in 1991), the data necessary to estimate the economic aspects of a water quality management programme for the waterways will be available. Based on such an analysis, the Government of Tamil Nadu must then decide whether or not to make the necessary investments to control pollution of the waterways, and thereby improve the quality of the urban environment of Madras City.

Glossary

anaerobic: a condition where no dissolved oxygen exists in the waterbody.

aquifer: underground porous layers used as a source of water supply, usually by means of wells.

Biochemical Oxygen Demand (BOD): The potential demand for oxygen which will be needed for oxidation of organic materials in the water by a combination of bacterial and chemical action. This is the most commonly used indicator of water pollution.

carcinogenicity: capability of causing cancer.

Coliform counts: number of bacteria of the types found in human digestive systems; measured per 100 millilitres, either as number of total coliform or faecal coliform bacteria.

disinfection: purification of drinking water or effluents using chemical agents such as chlorine, ozone to eliminate disease causing bacteria.

dissolved oxygen (DO): The oxygen dissolved in water - an important indicator of water quality.

ecological impact: The total effect of an environmental change, either natural or manmade on the ecology of an area.

ecosystem: Interacting complexes of living organisms and their physical environment.

effluent: The waste water discharged by an industry or municipality _after_ treatment.

endemic: (applied to) recurring diseases which are attributable to local causes.

estuary: area where fresh water meets salt water. Estuaries serve as nurseries and spawning or feeding grounds for large groups of marine life, and, provide shelter and food for birds and wildlife.

first flush: in a storm sewer, the condition when pollutants are heavily concentrated in initial run off at the onset of a storm.

forcemains: sewer or water pipes where flow is caused by pumping (and not by gravity).

groundwater: water contained underground in aquifers. Popularly termed "well water" made accessible by the use of energy, except in the case of springs or geysers.

heavy metals: important constituent in stream pollution. Metals which cause difficulties are lead, zinc, copper, nickel, chromium and mercury. These are often toxic and persistent.

index of dissimilarity: is a measure of species diversity. Pollution can cause a fall in this index over time, because it limits the kind of species that can exist in such an environment.

low flow augmentation: the process of supplementing low flow of a river (during the dry season) by releases from storage.

milligramme per litre (mg/1): equivalent to parts per million by weight - a measure of concentration.

mutagenicity: capability of causing a genetic mutation (which is often deleterious for human beings).

organic: referring to or derived from living organisms.

pathogenic: causing diseases (usually refers to bacteria or other organisms).

percolation: water passes slowly through small openings or pores in the ground.

permeable: surface which allows water (or other fluids) to penetrate and pass through.

pollution loading: the total weight of pollutant carried by a stream per unit of time.

receiving waters: Streams or other waterways which receive polluting discharges.

recharge: rainwater percolates through the ground, and, replaces the water in the aquifer that has been extracted.

salt water intrusion: Salt water being heavier than fresh, tends to flow under it and displace it, by penetrating porous formations from the coasts.

sand bar: drifting sand from the ocean forms a bar, and blocks the mouths of several rivers in peninsular India (and in other parts of the world).

sediment: popularly referred to as "silt" but clays, sands or organic substances are important components.

sewage: human wastes (excreta) carried by a water medium.

sewerage: underground system of pipes which transport sewage.

sink: ultimate receptacle which receives wastewater (could be land or sea).

species diversity: ratio between the number of species and the number of individuals per species. A healthy ecosystem often exhibits diversity, but there are exceptions.

stormwater runoff: see urban runoff.

sludge: the solid matter removed from wastewater by means of treatment.

sullage: wastewater from households other than sewage.

treatment plant: a facility for separation of wastewater into clean water and solids (sludge). Different levels of treatment are possible - primary (mechanical), secondary (biological) and tertiary (usually chemical) - depending of the nature of the waste and the legal requirements.

trihalomethanes: these are a group of organic compounds which contain a halogen such as chlorine. Many of these compounds are known to or suspected of causing cancer.

toxicity. the characteristic of being poisonous or harmful to plant or animal life.

urban runoff: all pollution emanating from an urban area except known point sources of treated or untreated wastes. These pollutants are carried by stormwater into storm sewers, and empties into the nearest available waterbody.

water course: a stream, rivulet or river where water flows from one point to another. Distinguished from lakes, ponds and tanks where water is stagnant. (A water body includes both kinds).

water pollution: the presence in water of chemical, physical biological and radiological characteristics detrimental to its intended use.

water quality standards: these are set (in India) by the Indian Standards Institution, as tolerance limits for various pollutants. They are legal requirements that have to be met.

watershed: land draining into a water course.

wetland: swamps and marshlands - these have unsuspected ecological value.

Note: Many of these definitions were obtained from Whipple (1977).

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APPENDICES

A. Improvements to the Sewerage System

B. Major proposals for Collection of Sewage

C. Improvements to the Stormwater Drainage System

D. Number of Points of Interlinkage between Sewage and Stormwater.

E. Quantity of Sewage Overflows into the Waterways

F. Sanitation in Slums Along the Waterways

G. Number of Unimproved Slums Along the Waterways

H. Incidence of Cholera in Divisions Proximate to the Waterways.

I. Tolerace Limits for Industrial Effluents

J. Tolerance Limits for Sewage Effluents

K. Tolerance Limits for Water Quality in Marine Coastal Areas.

A. IMPROVEMENTS TO THE SEWERAGE SYSTEM

	1875-85 (Rs.in lakhs)	1985-90 Proposals (Rs.in lakhs)
1. Collection System	316	614
2. Pumping stations and Force Mains	1329	1927
3. Treatment and Disposal	735	562
	2380	3103

Source: S.Daivamani (1986)

B. MAJOR PROPOSALS FOR COLLECTION OF SEWAGE

	Amount (Rs.in lakhs)
1. Conveying Sewage from Chepauk Office Complex to Napier Park Pumping Station.	26.40
2. Conveying Sewage from D.G.of Police, Q.M.C., Lady Willingdon to Ice House Pumping Station	7.50
3. Extending Sewer in General Hospital to Wall Tax Road Pumping Station	15.00

(These projects will considerably reduce the load of raw sewage entering the Buckingham Canal and the Cooum River)

Source: Draft Task-force Reports(1987)

C. STORMWATER DRAINAGE IMPROVEMENTS

	Kms of Drains	Cost (Rs.in lakhs)
Completed Works		
1. Phase I Construction	N.A.	40.60
2. Madras Urban Development Project I	13	75.00
3. Madras Urban Development Project II	42	151.36

	Kms of Drains	Cost (Rs.in lakhs)
4. Extended Panchayat Areas	N.A.	25.00
Work-in-Progress		
1. Reconstruction of damaged drains	11	82.88
2. Extended Panchayat areas	15	155.70
3. North Madras area	8	173.35
Proposed Projects	200	2000.00

Note: Atthe end of 1987, the total length of the drainage system would be 1067 Km, leaving a balance of 533 Km of roads that need drains.

Source: Draft Taskforce Report (1987)

D. NO.OF POINTS OF INTERLINKAGES BETWEEN SEWAGE AND STORMWATER DRAINS

Year	No.of Points
1984-85	722
1985-86	599
1986-87	517
1987-88	377
1988-89	125

Source: Draft Taskforce Report (1987)

E. QUANTITY OF SEWAGE OVERFLOWS INTO THE WATERWAYS 1986

Waterway	No.of Points	Quantity (mld)
Cooum River	27	20
Buckingham Canal	8	14
Adyar River	-	-
	35	34

Source: Draft Taskforce Report (1987)

F. SANITATION IN SLUMS ALONG THE WATERWAYS

Waterway	No. of slums	No. having Sanitation*	No. lacking Sanitation
Cooum River	71	27	44
Buckingham Canal	165	41	124
Adyar River	70	31	39
	306	99	207

* either connected to sewerlines or has septic tank

Source: Draft Taskforce Report (1987)

G. NO. OF UNIMPROVED SLUMS ALONG THE WATERWAYS

Waterway	Huts	Households	Population
Cooum River	3041	4250	22,525
Adyar River	2705	3800	18,600
Buckingham Canal	6791	9500	47,350
Otteri Nullah	2090	2925	15,500
Total	14,627	20,475	103,975

Source: MMDA (1988) "Slums Along Cooum and other Waterways"

H. INCIDENCE OF CHOLERA IN DIVISIONS PROXIMATE TO THE WATERWAYS (1978)

	Incidence (No. of cases/1000 population)		
Waterway	>4	2-4	<2
Cooum	None	1 (69)	19
Buckingham Canal	3 (35,41,89)	1 (90)	23
Adyar	-	-	6
Otteri Nullah	-	-	7
Total	3 divisions	2 divisions	55 divisions

Note: Figure in brackets is the division number

Divisions No.	Name
35	Choolai
41	Vyasarpadi
89	Triplicane
69	Pudupet
90	Marina

Source: Institute of Community Health, Taramani

I. TOLERANCE LIMITS FOR INDUSTRIAL EFFLUENTS DISCHARGED INTO INLAND SURFACE WATERS

(IS:2490-Part I)

Suspended solids	100	Copper	3.0 mg/l
Dissolved solids	2100	Zinc	5.0 mg/l
Ammoniacal Nitrogen	50	Selemium	0.05 mg/l
BOD	30	Nickel	3.0 mg/l
COD	250	Boron	2.0 mg/l
Arsenic	0.2	Cyamide	0.2 mg/l
Mercury	0.01	Chloride	1000 mg/l
Lead	0.1	Fluaride	2.0 mg/l
Cadmium	2.0	Phosphate	5.0 mg/l

Chromium	0.1	Sulphate	1000 mg/l
Total Chromium	2.0	Sulphide	2.0 mg/l
oil and grease	10.0	Phenolic Compounds	1.0 mg/l

p^H : 5.5 - 9.0 units

Source: Indian Standards Institution (1981)

Note: Some of the limits are higher if the discharge is into public sewers, notable,. Suspended solids-600, BOD 350, Oil and grease-20 Zinc -15, Fluoride-15, and Phenolic compounds - 5 mg/l

J. TOLERANCE LIMITS FOR SEWAGE EFFLUENTS DISCHARGED INTO INLAND SURFACE WATERS (IS:4764 - 1973)

Total suspended solids - 30 mg/litre

5 Day-Biochemical Oxygen Demand 20 mg/litre

Source: Indian Standards Institution (1973)

K. TOLERANCE LIMITS FOR WATER QUALITY IN MARINE COASTAL AREAS AFTER RECEIVING DISCHARGES (IS: 7967-1976)

Characteristic	Tolerance Limit
Colour and Odour	No noticeable colour or offensive odour
Floating Material	No visible sewage or industrial waste
Suspended Solids	No visible solids of sewage or industrial waste
p^H value	6.5 - 8.5
Free Ammonia	1.2 mg/l (max)
Phenolic Compounds	0.1 mg/l (max)
Dissolved Oxygen	3 mg/l (min)
Pesticides (as Cl)	0.0002 mg/l (max)
Arsenic	0.2 mg/l (max)

Mercury	0.0003 mg/1 (max)
Oil and grease	0.1 mg/1 (max)
BOD - 5 day	5 mg/1 (max)
Coliform bac teria (MPN Index per 100 ml)	1000
Bio-assay Test (96 hour)	90% (min)

Source: Indian Standards Institution (1976)

Note: These limits would apply to the coastal area except for the harbour, where oil and grease 10 mg/1 and coliform bacteria - 2500 standard is applicable.